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AN AUTOMATIC TIT-TAT-TO MACHINE.*

FRANK T. FREELAND,

University of Pennsylvania, Class of 1879.

The problem of designing a machine which would play one of the games of skill, has been attempted many times. Several automata have been constructed which would play the game of chess; but it was always found upon investigation, that their motions were controlled by a hidden confederate. The infinite number of variations in chess renders the construction of a true chess automaton impossible. Mr. Babbage, the inventor of the difference engine, in his ninth Bridgewater treatise, refers to the possibility of constructing an automaton which would play a much simpler game, that of tit-tat-to. A gentleman of this city has invented and made some drawings of such an automaton, working upon the principle of a

* UNIVERSITY OF PENNA., PHILA., *November 9th*, 1878.

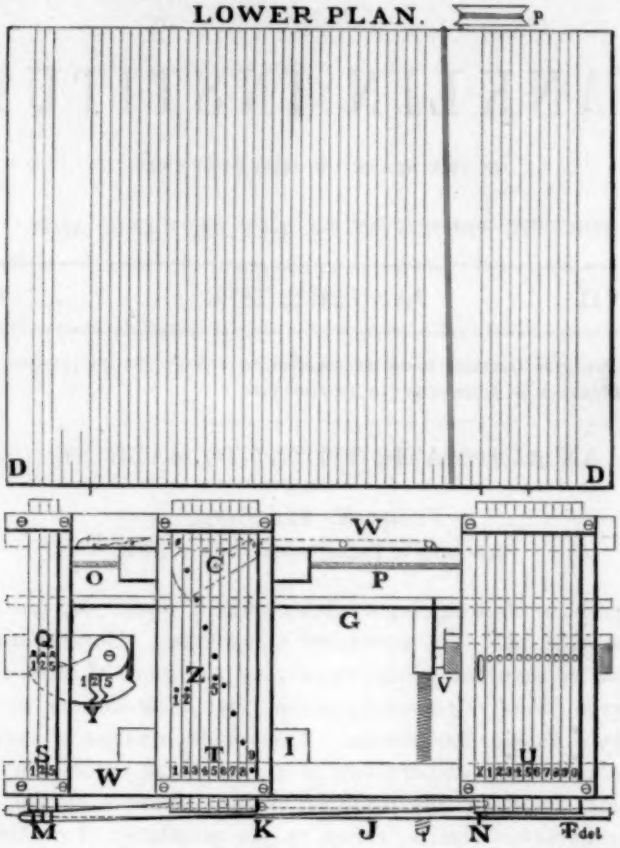
Dear Sir:—I hand you herewith, description and drawings of the automatic Tit-Tat-To Player, exhibited at your last meeting. The invention displays so much mechanical genius that it cannot but prove of interest, and perhaps of service, to all mechanicians.

Respectfully,

WM. D. MARKS.

To J. B. KNIGHT, ESQ., Secretary Franklin Institute.

movable Jacquard loom card. The machine herein described works upon an entirely different principle, that of a *mechanical table*, which contains all the possible variations of the game.



The game of tit-tat-to is played by two persons. A double cross is drawn upon a sheet of paper. One of the players chooses a cross (×) for his mark, and writes it in one of the spaces 1–9. The other player chooses a zero (0), and writes it in one of the remaining spaces, and so on alternately. The game is won by the player who first succeeds in getting three of his marks in a row. If the spaces are all filled before either player gets a row, the game is drawn.

1	2	3
4	5	6
7	8	9

The following is an exhaustive analysis of the game of tit-tat-to, for a machine to play the game, under the conditions that the

machine shall always play the best move; and that when the opponent, during the first three moves of each game, wishes to play one of two or four symmetrical moves, he shall take the one having the lowest number.

THE OPPONENT BEGINS.

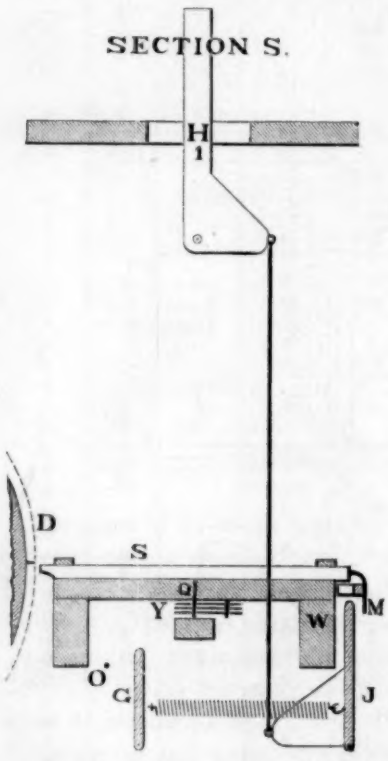
[These games will be found upon the *Surface of the Cylinder*, lines 1—74 inclusive.]

THE MACHINE BEGINS.

0	×	0	×	0	×	0	×	0	Res.
1	2	5	9	7	4	3			0
					367	4			0
			34678	9					0
	3	4	7	5	9	6			0
					268	9			0
			25689	7					0
	5	9	2	8	7	3	4	6	0
							6	4	—
					345	7			0
			3	7	4	8			0
					268	4			0
			6	4	7	3	2	8	—
							8	2	0
					238	7			0
	6	7	4	5	3	9			0
					289	3			0
			23589	4					0
	9	3	2	7	4	5			0
					568	4			0
			45678	2					0
2	1	5	8	7	3	6	4	9	—
					469	3			0
			34679	8					0
	4	1	3	5	9	8			0
					678	9			0
			56789	3					0
	5	1	3	7	4	6	8	9	—
							9	8	—
					689	4			0
			46789	3					0
	7	1	3	5	9	8			0
					468	9			0
			45689	3					0
	8	1	3	9	5	7	4	6	—
							6	4	0
					467	5			0
			45679	3					0
5	1	2	8	7	3	6	4	9	—
							9	4	0
					469	3			0
			34679	8					0
	2	1	9	4	6	7			0
					345	6			0
			34678	9					0

The method of transforming this symbolic table into a mechanical one, will be obtained by a comparison of it with the *Surface of the Cylinder*, beginning at line 75. There are one hundred and fifty lines upon the cylinder. The omitted ones may be obtained from the latter part of the above table. Our 1st, 2d, 3d and 4th moves in any game are set down in the columns T I, II, III and IV. Each column contains nine vertical lines. The figure 1 is represented by a pin upon the first line; 2, by a pin upon the second line, etc. The machine's answering moves are set down in the column U, upon the same horizontal line as ours. Whenever its move gives it three in a row, another pin is put upon the line U0. The row of pins Ux affords a hold to a catch. When the machine begins, its first move is set down in the column S.

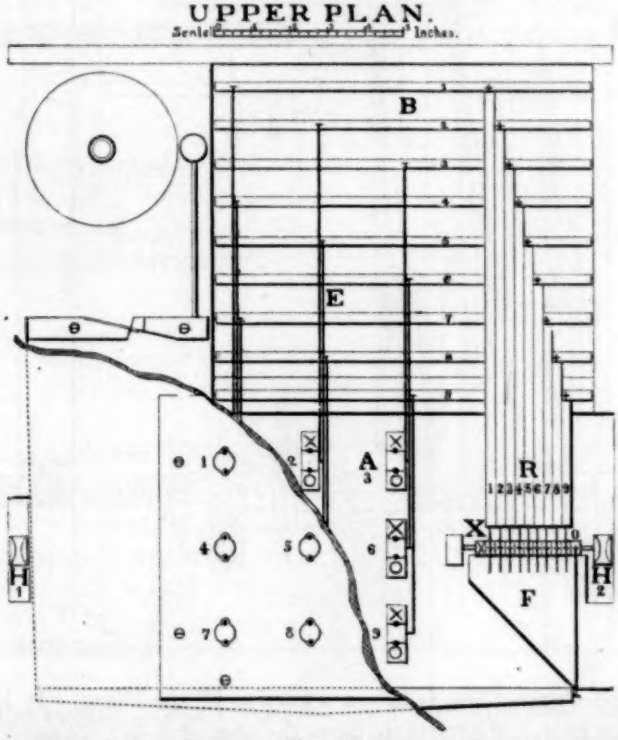
DESCRIPTION.—In the *Lower Plan*, the cylinder *D* is represented, its surface being prepared as described above. The cord, weight and pulley *p*, give it a tendency to turn toward us. In front of it are the two cross-beams or ways *W W*. On them the carriage *I* runs. The cord *P*, running over a pulley to a weight, gives the carriage a tendency to move to the right. The carriage has a catch *C*, which engages with four pins set in a groove in one of the ways. Whenever the catch *C* is pushed, the carriage *I* moves a space to the right, equal to one column of the table. The wire *O* is to draw it back to its first position. On the carriage are nine sliders, *T* 1–9. When they move forward, they engage with the pins upon the cylinder. *T* 1, 2 and 5 have the pins *Z* 1, 2 and 5 in them, which project below the carriage.



A platform is secured to the ways at the left. On it are the

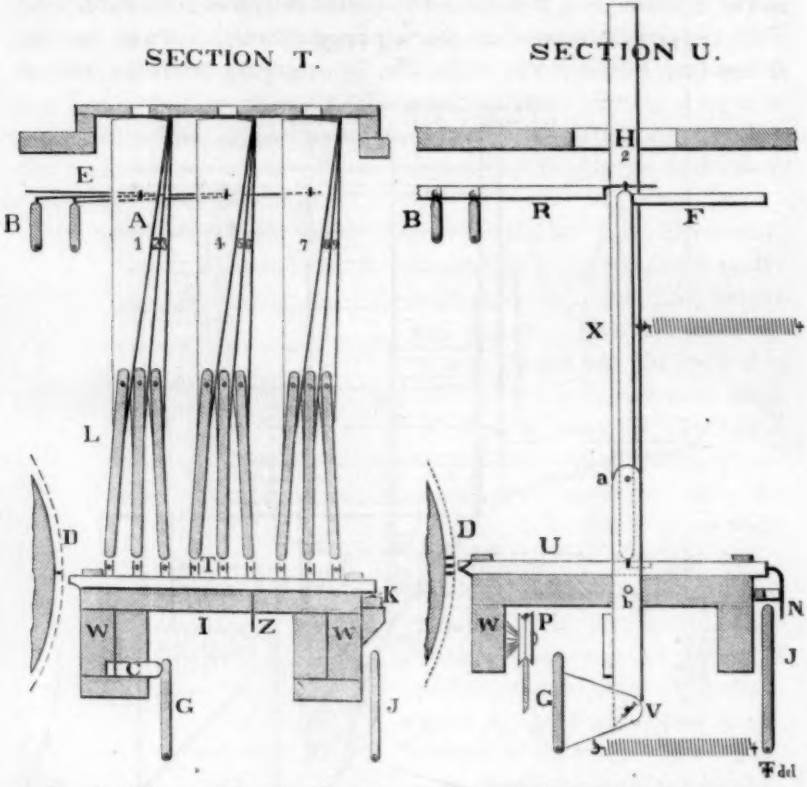
sliders *S* 1, 2 and 5, having in them the pins *Q* 1, 2 and 5, which project below the platform. Supported on a bracket, under the platform, are the flat, horizontal cams *Y* 1, 2 and 5. When the carriage is in its first position, the pins *Q* 1, 2, 5 and *Z* 1, 2, 5 engage with these cams. They are of such a shape, that when the slider *T* 1, 2 or 5 moves backward, the pin *Z* 1, 2 or 5 rubs over the pointed end of the cam *Y* 1, 2 or 5, and so pushes *S* 1, 2 or 5 forward.

At the right is secured to the ways a platform, on which are the sliders Ux, 1–9, 0. The slider *Ux*, by engaging with the row of



pins *U*x, locks the cylinder. *U* 1–9 discover the answering move. *U*0 determines the striking of the bell. These sliders are set at a higher level than the others, so that when they move forward, they impinge upon the pins, instead of going under them. *K* is a horizontal lever, pivoted at its centre. *S* 1, 2, 5 and *Ux* have in their ends bent wires, *M* and *N*, so that when *S* 1, 2 or 5 moves forward, *K* pulls *Ux* backward. *J* is a vertical leaf, pivoted at its lower

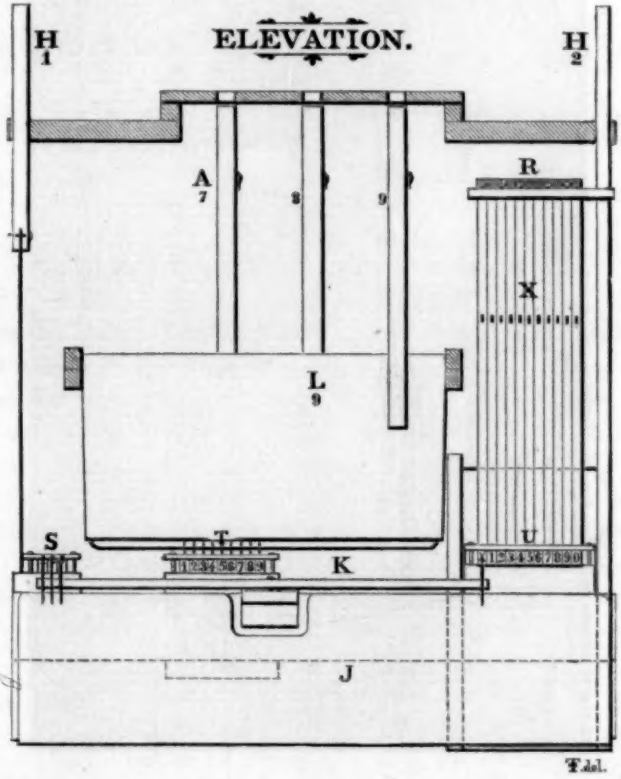
corners, and connected by a double bell-crank with the lever *H* 1, as shown in *Section S*. When *H* 1 is pushed forward, *J* draws out the catch *Ux* and the sliders *S* 1, 2 and 5. *G* is a vertical leaf, pivoted at its lower corners. When it moves toward the cylinder, it releases the carriage by striking the catch *C*. *G* has secured to it an arm with a pin in it, as shown at *V*, *Section U*.



In the *Upper Plan*, is shown a portion of the board. It has nine openings in it. Under them move the arcs *A* 1–9. There is a cross (×) on one end of each, and a zero (0) on the other. These arcs are secured to the vertical leaves *L* 1–9, which are pivoted at their upper corners. By long wire teeth they gear into the sliders *T* 1–9 in such a way, that they do not get out of gear when the carriage moves to the right or left. See the *Elevation* and *Section T*.

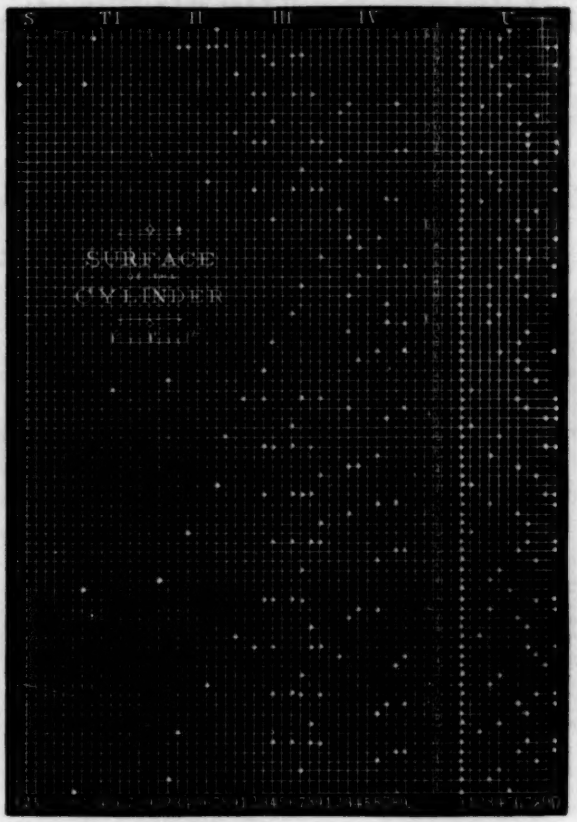
In *Section U*, the levers *H* 2 and *ab* are represented. They are pivoted on each side of the platform at *b*, and firmly united by a

cross-piece under the platform. On the lower end of *ab* is fastened an inclined plate *V*. When the lever *H* 2 moves backward, the plate *V* lifts the arm of *G* by the pin on it, and so releases the carriage. From *ab* to *H* 2 at the point *a* runs a stout wire. On it are strung the vertical levers *Xx*, 1–9, 0. Their upper ends are held back against the plate *F*, which serves as a fulcrum, by the



springs as shown. Their lower ends are geared into the sliders *Ux*, 1–9, 0. When *H* 2, containing the point *a*, moves forward, the levers *Xx*, 1–9, 0 move forward, their upper ends being their fulcrums, pushing the sliders *Ux*, 1–9, 0 forward. If one of these impinges on a pin, it stops, and becomes the fulcrum of the *X* belonging to it. Then the upper end of that *X* goes forward, elongating the spring. The slider *Ux* has a slot at its point of gearing, so that when it is carried forward it is left there. When the upper ends of

X 1–9 move forward, they strike the rods *R* 1–9, which are hooked to the vertical leaves *B* 1–9, pivoted at their lower corners. These are connected by the wire links *E* 1–9 with the arcs. When the upper end of *X*0 goes forward, it causes a bell to strike.



Operation.—The machine is wound up by setting all the arcs at their middle position, so that neither mark appears; then push *H* 1 and wind up the cylinder by a key at the left; push *H* 2 and it is locked; and lastly draw the carriage into its first position.

We make our move by putting an instrument like an awl into one of the holes of the arcs, and so moving it that the cross appears. Suppose we move 2, then slider *T* 2 goes forward. Release the cylinder from the catch by pushing *H* 1. The cylinder turns until the pin at T I 2, line 22, strikes the slider. On pushing *H* 2 forward,

the pin at U 5 will stop the slider *U* 5, and *X* 5 will push *R* 5 and *B* 5 forward. Then the wire *E* 5 from *B* 5 to *A* 5 will so move the arc that the zero (0) will appear at the opening 5. At the same time the slider *Ux* will move forward and lock the cylinder. When *H* 2 comes back, the carriage will move into position II, opposite the column T II. Suppose we then move 1, the cylinder will stop at line 23, and the machine moves 3, the carriage taking position III. If we now move 7, the cylinder will stop at line 24, the machine moves 4, and the carriage takes position IV. If we move 6, the cylinder stops at line 25, and the machine moves 8. [If we had moved 8 or 9, the cylinder would have stopped at line 26, the machine would have moved 6 and won. The pin on *U*0 causing the bell to strike.] Finally we move 9, and the game is drawn. The machine is then wound up.

If we wish the machine to begin, we move one of the arcs so that the zero appears. Suppose that we so move 1. The slider *T* 1 is moved backward, hence *S* 1 is pushed forward by *Y* 1, and *K* pulls the catch from the cylinder, which turns until the pin at S 1, line 75, strikes the slider *S* 1. Then we make our move, suppose it to be 2. On touching *H* 1, the cylinder remains at line 75, and on pushing *H* 2, the machine moves 5, the carriage taking position II. Now, if we move 9, the cylinder stops at line 76, and the machine moves 7, the carriage taking position III. If we then move 4, the cylinder stops at line 77, the machine moves 3 and wins, the bell proclaiming the fact; but, if we move 3, 6 or 8, the cylinder stops at line 79, the machine moves 4. So it wins in either case.

This machine, the first one ever constructed, was built in the summer of 1878, and exhibited at the Franklin Institute, October 16, 1878. It is now at the University of Pennsylvania, where, since its final adjustment, it has played a large number of games without losing a single one.

PHILADELPHIA, *November 8th*, 1878.

DOES THE WEARING POWER OF STEEL RAILS INCREASE WITH THE HARDNESS OF THE STEEL?*

By CHAS. B. DUDLEY, Ph. D.,
Chemist, Pennsylvania R. R. Co., Altoona, Pa.

While working, during the summer of 1877, upon the "Chemical Composition and Physical Properties of Steel Rails," the results of which are given in my report† with this title, I was struck with the surprising wear which some of the rails, which would ordinarily be called soft rails, had endured. At that time I knew of no chemical measure of softness except low carbon, and I found that a number of rails with low carbon had endured as high or higher tonnage, with apparently as little loss of metal by wear, as those with higher carbon. My own work on steel rails that summer did not embrace any definite experiments as to the amount of metal worn off the rail per million tons which had passed over it; and so I could get no more definite answer from that work, to the question at the head of this paper, than was given by comparing the appearance of the worn section of the rail with its tonnage. This comparison, however, served to arouse in my mind the query, whether the commonly received opinion as to the relation between the hardness and wearing power of steel, is correct, as applied to steel rails. This opinion, if I am right, is: the harder the steel, the better will be the wear, and the limit of hardness is simply one of safety; hard, brittle steel being, of course, more liable to break than soft, tough steel. The query, although aroused, did not bear any immediate fruit, and, as will be evident to any one reading it, the report above referred to was written with the commonly received opinion in mind. Since that time I have collected a little information upon this subject, which I should be glad to submit to the Institute, if for no other purpose, for the sake of arousing attention, and directing study to the question of hardness *versus* wear in steel rails.

Before making known the information, however, permit me a few words in reference to hardness. How shall we measure the hardness of steel? Of the various ways of getting indications as to the hard-

* A paper read before the Institute of Mining Engineers, October 15th, 1878.

† See vol. cvi, page 361.

ness of steel, which are known, three will serve our present purpose. These are: 1st. High carbon. It is generally agreed, I think, that at least within proper limits, the greater the amount of combined carbon in a piece of steel, the harder the steel, and I need not do more than mention this fact to obtain your assent to it. 2d. The physical test of punching, measures the hardness of steel. Data in regard to the wearing power of hard and soft rails, determined in this way, will be given below. 3d. The sum of the phosphorus units in a piece of steel measures its hardness. Phosphorus units, as is fully described in my report above referred to, are an attempt to measure the hardness of steel by estimating the combined hardening power of the phosphorus, silicon, carbon and manganese in a piece of steel, in terms of the phosphorus. Now, by measuring hardness in these three ways, I have been able to collect the following information with regard to the relation between the hardness and wearing power of steel rails.

1. Some two years ago the Penna. R. R. Co., in view of the unsatisfactory wear it was obtaining from its steel rails, asked to have more carbon put into its rails, with a view of making them harder, to resist wear. Before the increase, the limits of carbon for rails to be used on Penna. R. R., was from 0·30 to 0·50 per cent. After the increase, the limits were from 0·40 to 0·50 per cent., thus securing on the average perhaps, about a tenth of a per cent. more carbon in the steel. Now, Mr. W. H. Brown, Chief Engineer, Maintenance of Way, Penna. R. R., informs me that these rails of higher carbon are giving poorer wear than before the lower limit of carbon was raised. This opinion of Mr. Brown is based on his observation of the wear of these higher carbon rails, and on the number of renewals of these rails, rendered necessary by the condition of the track.

2. Mr. J. T. Smith, General Manager of the Barrow Hæmatite Steel Works, England, read a paper on "Bessemer Steel Rails," before the Institution of Civil Engineers, in 1875.* The object of the paper was to show that Bessemer steel may be produced constant in quality, and that certain inexpensive tests may be applied, which shall determine the quality of the metal for railway purposes. The test proposed by Mr. Smith was to punch the fish-plate holes with a registering-press, the quality of the metal being judged of by the

* Proceedings Inst. Civil Eng., vol. xlii, p. 69.

force required to punch the holes. This would render it possible to inspect and judge of the quality of every single rail. I must refer you to Mr. Smith's paper for further information upon this point.

The point which is of especial interest to us now is that Mr. Smith examined thirty rails which had been eight years in service on the main line of the Furness Railway. The rails were divided into two classes, on the basis of the force required to punch a hole $\frac{1}{8}$ of an inch in diameter, through the web $\frac{3}{4}$ of an inch thick. Twenty of the rails required for this purpose a force varying from $46\frac{1}{4}$ tons to $52\frac{1}{2}$ tons, and were therefore called soft rails; while the remaining ten rails required for the same purpose a force varying from $56\frac{3}{4}$ tons to $82\frac{1}{2}$ tons, and were therefore called hard rails. The average force required to punch the soft rails was about 49 tons, while for the hard rails this average force was about $64\frac{3}{4}$ tons. Mr. Smith likewise gives the determinations of the carbon in these rails. In the twenty soft rails the carbon varied from 0·28 to 0·32 per cent., or an average of 0·30 per cent., while in the hard rails the carbon varied from 0·36 to 0·57 per cent., with an average of 0·44 per cent. Now as to the wear of these rails. The wear seems to have been determined by taking the difference between the original weight of the rail per yard, and the weight per yard of the worn rail, and then reducing this to the percentage of the metal worn off. Now in the twenty soft rails, this percentage of wear varied from 10·38 to 16·24 per cent., with an average wear of 13·54 per cent., while in the ten hard rails the percentage of wear varied from 12 to 20·53 per cent., with an average of 15·18 per cent. These figures seem to me very significant, and to warrant Mr. Smith in the conclusion which he expresses, viz.: "Contrary to what might have been anticipated, greater hardness has not conduced to the longevity of the rails, and the softer ones show the minimum of wear."

3. With regard to the wear of rails, in which the hardness is measured in phosphorus units. On May 23d, 1876, Mr. R. Price Williams read a paper before the Institution of Civil Engineers, on "The Permanent Way of Railways." * In his investigation into the subject of steel rails, Mr. Williams found such a surprising difference in the wear of certain rails which were side by side, and therefore subjected to the same traffic, that he had seven of these rails from the Great Northern Railway analyzed by Mr. Edward Riley. The

* Proceedings Inst. Civil Eng., vol. xlvi, p. 147.

results as to wear are given in number of million tons traffic per $\frac{1}{16}$ inch worn off the rail. Four of these seven rails, measured in phosphorus units, sum up 31, 30, 32 and 25, and may, therefore, be called, in comparison with the others, soft rails. The remaining three rails sum up, in phosphorus units, 38, 40 and 47, and may be called hard rails. The rails are numbered, in Mr. Williams' series, Nos. 9, 17, 18, 21, 22, 23 and 24. Nos. 17 and 18 were side by side, and subjected to the same traffic. The phosphorus units in No. 17 are 38, and in No. 18, 30, one hard and one soft, as is seen. The hard rail withstood 5,251,000 tons per $\frac{1}{16}$ inch wear, while the soft one withstood 8,402,000 tons per $\frac{1}{16}$ inch wear. Again, Nos. 23 and 24 were side by side. The phosphorus units in No. 23 were 47, and in No. 24, 25, one hard and one soft, as before. The hard rail withstood 15,531,000 tons per $\frac{1}{16}$ inch wear, while the soft rail withstood 31,061,000 tons per $\frac{1}{16}$ inch wear. In Nos. 21 and 22, which were side by side, the hard rail shows a little the best wear, the figures being 9,283,000 tons per $\frac{1}{16}$ inch wear, for the hard rail, and 7,676,000 tons per $\frac{1}{16}$ inch wear for the soft rail. If now we take the average of the tonnage per $\frac{1}{16}$ inch wear for the three hard rails and the four soft ones, the result becomes quite striking. The four soft rails withstood an average tonnage of 15,567,000 tons per $\frac{1}{16}$ inch wear, while the three hard rails withstood, on the average, only 10,055,000 tons per $\frac{1}{16}$ inch of the metal worn off. The chemical composition of the one rail of this series, which withstood the highest tonnage, viz., 31,061,000 tons per $\frac{1}{16}$ inch wear, is so remarkable that I cannot forbear quoting the full analysis. This rail sums up 25 in phosphorus units, and contains: carbon, 0·270 per cent.; phosphorus, 0·100 per cent.; silicon, 0·020 per cent.; manganese, 0·259 per cent.; sulphur, 0·051 per cent.; copper, 0·025 per cent.; and iron, 99·475 per cent.

If enough has been said upon this subject to direct attention to it, my object will have been accomplished. It is perhaps too soon to venture conclusions. The indications would seem to be, however, that under the conditions of wear to which a steel rail is subjected, viz., rolling friction, unlubricated surfaces, and great weight with small bearing surface, the quality of the metal necessary to most successfully withstand the disintegrating forces, is best expressed by the word toughness, and not by hardness.

Altoona, Pa., *Oct.* 12*th*, 1878.

WATER-TUBE AND FIRE-TUBE BOILERS.

An Account of the Experiments made by Chief Engineers Loring and Baker, U. S. Navy, on a Horizontal Fire-Tube and a Vertical Water-Tube Boiler, at the Washington Navy Yard, to ascertain their relative Economic Vaporizations with different kinds of Coal.

By Chief Engineer ISHERWOOD, U. S. Navy.

At the time the compound engine was introduced into the Navy of the United States, several modifications were attempted of the ordinary cylindrical boiler habitually employed with it. These modifications were made for the purpose of obtaining either better economic vaporizations, or of placing the grate and heating surfaces in a less breadth of shell; and among them was an arrangement, in a cylindrical shell, of vertical water-tubes immediately over the furnaces, in exactly the position occupied by the horizontal fire-tubes of the ordinary boiler.

This system of vertical water-tubes which had been introduced with rectangular shells into the steamers of the United States Navy some eight years before the writer became Chief of the Bureau of Steam Engineering in the Navy Department, was continued by him after careful experiments had proven that, with such proportions as were practicable for marine boilers, the vertical water-tube gave the best economic vaporization; in other words, a pound of coal burned in the vertical water-tube boiler vaporized more pounds of water than when burned at the same rate in a horizontal fire-tube boiler having the same proportions.

The vertical water-tube boiler which was originally invented by the Earl of Dundonald, had been perfected in its constructive details by Chief Engineer Daniel B. Martin, of the United States Navy, and was known in America as the "Martin Boiler." It was, with the exception of a few merchant steamers, used exclusively in the Navy, where it always gave the greatest satisfaction; but in Great Britain it never obtained the like success. The large steam-engine building firms, both there and in America, opposed its use, though certainly without regard to its engineering merits. These firms take contracts for a round sum to produce either a stipulated horse-power, or a stipulated speed of vessel over a measured mile, independent of the

weight of coal consumed; and as the vertical water-tube boiler is much heavier, more bulky and more costly for equal maximum weights of steam supplied per hour, and as they pay for the construction of the boiler, and not for the coal it consumes, they naturally prefer the cheapest type.

The vertical water-tube boiler obtains a greater economic result from the coal, solely by virtue of the superior arrangement of its tubes for heat absorption; the furnace and smoke-connections being the same as in the ordinary type, and the position of the tubes relatively to them being also the same, whatever difference may be found in the economic result, must be entirely due to the tubes. In other words, of a given quantity of heat of given intensity thrown upon equal tube-surface in the two types of boiler in equal time, the vertical water-tubes will absorb more than the horizontal fire-tubes; and, as a necessary consequence, the gases of combustion will enter the chimney at a lower temperature and produce a less draught. One reason why the vertical water-tubes are more absorbent of heat than the horizontal fire-tubes, is that the former stands across or at right angles to the current of the gases of combustion, thereby continually breaking it up and commingling its constituents, each row of tubes being as a consequence impinged on by freshly mixed gases as they proceed from the back smoke-connection to the uptake; while the horizontal fire-tubes, lying in the direction of this current, have no such mechanical action upon it, the particles of the hot gases entering at the smoke-connection end of a horizontal fire-tube retain their relative positions until they emerge from its uptake end, so that the same particles are in contact with the tube-surface from one end to the other during the second or two of their passage. Thus, the core, or central mass of the gases in each tube, may have at its exit a much higher temperature than its surrounding film in contact with the tube-surface; while, in the vertical water-tube boiler, the mass of horizontally moving gases emerging into the uptake must have a nearly uniform temperature due to their thorough mixture by beating against and eddying around the vertical tubes which obstruct their progress. It is highly probable, too, that the intimate intermingling of the gaseous current from the furnaces, effected by this mechanical action of the vertical water-tubes, causes the combustion of a portion of its constituents which might otherwise escape combination. Of course, the obstruction opposed by the vertical water-tubes to the current of

the gases of combustion, mechanically lessens the draught of the chimney in addition to the lessening that results from the lower temperature of those gases comparatively with that of the gases entering the chimney from the horizontal fire-tube boiler; so that the vertical water-tube boiler has a less draught than the horizontal fire-tube boiler, both by the amounts due to the lessened temperature of the current of gases of combustion entering the chimney and due to the mechanical obstruction opposed to that current by the tubes as a consequence of their position. Hence, other things equal, the maximum rate of combustion in a vertical water-tube boiler is less than in a horizontal fire-tube boiler, and a greater quantity of the former is required to supply at the maximum the same quantity of steam in equal time as the latter, notwithstanding the greater vaporization per pound of coal consumed in the former. The greater economic efficiency of the vertical water-tube boiler and its less potential efficiency, are thus inseparably joined as cause and effect when the draught is controlled by the chimney alone; but when mechanical means are employed to produce the draught, as a fan-blower for example, then, both in economic and potential efficiency is the vertical water-tube boiler superior to its rival.

In general, as the result of his very extended and carefully conducted experiments, the writer found that, other things equal, the rate of combustion at the maximum by the chimney alone in the case of the horizontal fire-tube boiler, was 50 per centum greater than in the case of the vertical water-tube boiler; but, that the economic vaporization at those relative rates was 25 per centum less than in the latter. Hence, for equal quantities of boiler, the horizontal fire-tube produced in equal time, at the maximum 25 per centum, more steam than the vertical water-tube, but at an expense of 25 per centum more coal per pound weight of steam. In this fact will be found the principal reason of the little use by contractors for steam machinery of the vertical water-tube boiler; and their practice may, in measure, be defended for steamers making short voyages, but just in proportion as the voyages lengthen does that practice cease to be judicious. The engineer has to look upon the boiler and the coal to be carried as a whole, with a proportion between them variable according to circumstances. He has to consider that a certain space and displacement are allotted in the vessel to the two combined, and it is a test of his skill to so proportion them to each other, for the

different types, as to obtain from them the greatest number of miles steaming. The greater the economic efficiency of a certain type of boiler, though accompanied by a less potential efficiency, the more of it and the less of coal can be properly placed in the vessel to steam a given distance at a given speed; and the less the economic efficiency of a certain type of boiler, though accompanied by a greater potential efficiency, the less of it and the more of coal can be properly placed in the vessel to steam the given distance at the given speed. The best type of boiler to be adopted, is the one which enables the vessel, with a given space and displacement assigned to boiler and coal, to make the given distance at the given speed, with the least coal. Hence, for naval steamers making long voyages, the vertical water-tube boiler gives better results than the horizontal fire-tube boiler, and better just in proportion to the number of days the vessel is required to be able to steam at the given maximum speed. Such were the considerations which led the writer to prefer the vertical water-tube boiler to the horizontal fire-tube boiler for the steamers of the United States Navy, and he believes their soundness will bear the closest scrutiny. The boilers he designed had rectangular shells, and were braced for a working pressure of 40 pounds per square inch, above the atmosphere; they allowed about 50 per centum more grate and heating surfaces to be placed in a given space than the cylindrical boilers carrying a pressure of 70 pounds; and it is very doubtful if any economic gain possible from the latter pressure can compensate the enormous increase of space required, especially when the value of space in a naval vessel is considered.

Compared with the horizontal fire-tube boiler, the vertical water-tube boiler, when steaming at the maximum over a given distance in a given time, is 25 per centum heavier, more bulky and costly; but it requires 25 per centum less weight of coal carried in the bunker. In weight and bulk, this less weight of coal offsets in measure the greater weight and bulk of the boiler, and if the time of steaming extends to eight or ten days, much more than offsets them, while the much greater cost during a year's steaming of the 25 per centum additional coal with the horizontal fire-tube boiler, more than offsets the difference of cost between it and the vertical water-tube boiler.

The circulation of the water and the extrication of the steam over the *entire* tube-surface, are much more rapid with the vertical water-

tube than with the horizontal fire-tube boiler; and, from these causes, the unit of surface in the former is much more efficient as a steam-producer, than the unit of surface in the latter.

All the water vaporized by the vertical water-tubes, is supplied to them from the space between the crown of the furnace and the lower tube-plate, and, in ascending, is not obstructed by any mechanical impediments, but, being guided by the vertical tubes themselves, takes the shortest path, and rises with the maximum velocity due to the conditions of temperature and height of column, passing with this velocity over the *entire surface of the tubes*. Hence, in a given time, the greatest possible number of particles of water would be brought in contact with a given tube-surface, and the bubbles of steam formed on that surface would be swept off by that rapid circulation, with corresponding speed. These advantages accrue to the vertical water-tube by reason of the parallelism of the tube with the ascending column of water, and by reason of the tube protecting the entire ascending mass of water from being broken in upon by lateral currents.

But with the horizontal fire-tubes, these conditions are all reversed. Those tubes, lying at right angles to the ascending current of water, act as mechanical obstructions, and consequently impede its velocity; beside which, the water vaporized by the horizontal tubes is supplied to them, not only vertically from the water space between the lower row of tubes and the crown of the furnaces, but horizontally from the water spaces at the sides of each group of horizontal fire-tubes, and coming in between the rows as cross-currents to the ascending mass, break in upon and lessen its vertical velocity. Neither the vertical nor the horizontal cross-currents can pass with maximum velocity over the *entire surface* of the horizontal tubes, because that surface being convex in opposition to these currents, can have only a line swept tangentially by them with the maximum velocity, which, existing only in the *least* water spaces between the tubes, is able to sweep only a line of their surfaces vertically and horizontally. There must be, therefore, in a given time, fewer molecules of water brought into contact with a given tube-surface in the case of the horizontal fire-tube, than in that of the vertical water-tube.

With the vertical water-tube boiler, brass tubes are indispensable, as iron ones last only from one to two years, owing to the rapid corrosion of their lower ends. The lower one-fourth of an iron vertical

water-tube will be corroded entirely through, while the upper three-fourths will be unaffected, but brass tubes will much outlast the boiler. The corrosion of the iron tubes is nearly as rapid with jet condensers as with surface condensers, as it takes place almost entirely on the outside, being due to the sulphuric acid formed by the union of the sulphurous gases from the coal, with the moisture deposited on the tubes during each interval of steaming. This weak sulphuric acid trickles down the tubes, and remains around their lower ends, where there is also, generally, most soot. When, as sometimes in land boilers, the steaming is continuous the year around, with only occasional interruptions for cleaning, the iron vertical water-tube is as durable as the iron horizontal fire-tube, but it should never be employed with marine boilers.

The sweeping and replacing of vertical water-tubes are a little more difficult than in the case of horizontal fire-tubes; but they are far easier to be cleaned of scale, which can be entirely removed from the interior of water-tubes, but only partially from the exterior of fire-tubes; and the former have the advantage that the water level can be allowed to fall fifteen inches below their upper tube-plate, without injury from heat.

The vertical water-tubes require for their extraction and replacement, a height between their upper tube-plate and the boiler shell equal to their length. This condition cannot be had in a cylindrical shell, but if brass tubes are properly put in and well cared for, there will be no occasion to replace one during the life of the boiler. In the original construction of the boiler, the tube-box can be made complete, independently, with the tubes secured in their plates, and the whole then riveted into place.

In the case of a horizontal fire-tube and of a vertical water-tube boiler differing only in the tubes, all the other portions being the same, and the total grate and heating surface in the one being the same as the total grate and heating surface in the other; the weight of the former will be a little less than the weight of the latter in metal alone, exclusive of the water contained, but if the water be included, then the weights of both boilers will be about equal.

A modification of the ordinary cylindrical boiler, with horizontal fire-tubes returned above the furnaces, called the "oval boiler," has been found convenient in practice as enabling the grate and heating

surfaces to be placed in a less frontage. This so-called oval boiler has a semi-circular top and bottom of equal diameter, connected by flat vertical sides, making the height of the boiler greater than its breadth by the height of these sides which are, of course, tied across by braces. Such a shell is particularly well adapted for vertical water-tubes, the height of the flat vertical sides being made the same as the height of the tubes, the tube-boxes being placed directly between these sides, and braced to them.

Experimental Boilers.

To test the mechanical feasibility, and the economic vaporization of such an arrangement of vertical water-tubes as could be placed in a cylindrical shell, comparatively with the economic vaporization by horizontal fire-tubes placed in a duplicate shell, the Bureau of Steam Engineering of the Navy Department, constructed at the Washington Navy Yard, two high-pressure boilers of the marine type, for compound engines. The shells of these boilers were cylindrical, 10 feet in diameter, and 9 feet in length, exclusive of their sheet iron uptakes. Each shell contained two cylindrical furnaces 3 feet in diameter, with grates 6 feet in length. The two boilers were duplicates in all respects except tubes, those in the one being horizontal fire-tubes, and those in the other being vertical water-tubes; but, in both cases, the tubes occupied the same position, immediately above the furnaces. The heating surface of the tubes has been calculated for their *inner* circumference in both cases, and with this method of calculation the total heating surface of the horizontal fire-tube boiler is 1019 square feet, or 28·30 square feet to one square foot of grate surface; while, in the vertical fire-tube boiler, the total heating surface is 1104 square feet, or 30·67 square feet to one square foot of grate surface. In quantity of heating surface, therefore, the vertical water-tube boiler exceeded the horizontal fire-tube boiler $\left(\frac{1104-1019\times 100}{1019}=\right)$ 8·34 per centum, or about one-twelfth; but that this additional quantity had but very little influence on the economic vaporization, will be apparent when the rate of combustion (only 14·2 pounds per square foot of grate surface per hour, at the maximum) is considered, and the large proportion of heating to grate surface (28·30 to 1·00) existing with the boiler having the least heating surface. The cross area over the bridge-walls for draught,

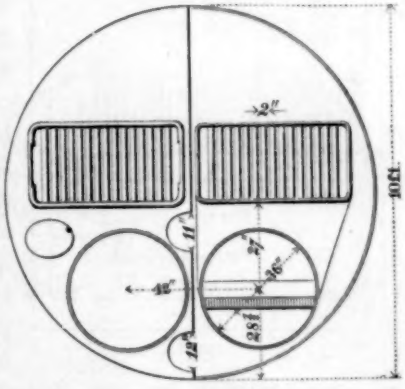
is the same in both boilers, namely 5·55 square feet, which is one square foot to each 6·40 square feet of grate surface. This proportion is the same through the tubes of the vertical water-tube boiler, but is much greater through the tubes of the horizontal fire-tube boiler, where it is one square foot of cross area to each 4·97 square feet of grate surface. This difference, in view of the fact that the cross area for draught over the bridge-walls is less than through the tubes, has no effect on the economic vaporization. The steam room in both boilers is of very nearly the same height and capacity.

The following is a detailed description of each boiler, together with its dimensions and proportions:

THE VERTICAL WATER-TUBE BOILER.

The shell of the vertical water-tube boiler is a cylinder with flat ends at right angles to its axis. This cylinder is 10 feet in diameter and 9 feet in length, externally; the uptake, which is of sheet-iron bolted to the front end of the cylinder, projects beyond this length. The plates of the shell are $\frac{11}{16}$ of an inch thick and double riveted. The flat ends of the shell above the tube-boxes are stayed directly across with iron rods $1\frac{3}{8}$ inches in diameter and 10 inches between axes, attached to double angle iron riveted vertically to the ends. All other flat ends are stayed with socket-bolts $1\frac{1}{8}$ inches in diameter and 6 inches between centres.

Fig. 1.

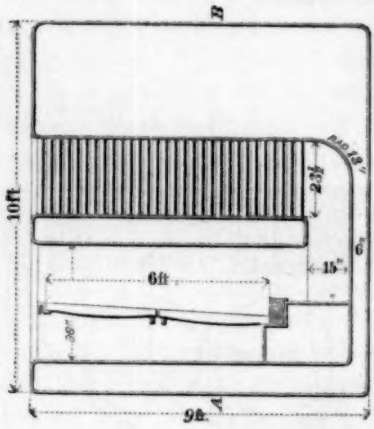


There are two furnaces contained in horizontal cylinders of 3 feet internal diameter and 7 feet 3 inches extreme length. The axes of these cylinders are in the same horizontal plane and 42 inches apart. The cylinders are composed of iron plates, $\frac{1}{2}$ inch thick, butted, and double riveted to inner welts below the grate-bars; they are single riveted to the boiler shell, and are in two lengths, flanged where the lengths meet at the centre and single riveted thereby. The grates within these cylinders are 6 feet in extreme length, composed of cast-

iron in two lengths of 3 feet each. The bridge-wall is cast-iron faced with fire-brick, and is 6 inches high above the level of the grates. The top of the grates is 18 inches below the crown of the furnace at the front, and 21 inches below it at the back.

Each furnace has a separate back connection 15 inches long lengthwise the boiler, with its top rounded on a quadrantal arc of 13 inches radius. Its back is flat and separated from the back end of the boiler shell by a flat water-space 6 inches wide, including thicknesses of metal. The bottom of the connection is a horizontal extension of the bottom of the cylinder containing the furnace, and the sides are flat. The inner side is vertical and rises from the horizontal diameter of the furnace. The outer side, at top, is a horizontal extension of the vertical side of the tube-box, from the lower edge of which it slopes inwards on a tangent to the cylinder containing the furnace. The cast-iron bridge-wall of the furnace is extended clear across the connection, so as to occupy the whole of the lower portion.

FIG. 2.



Here are two horizontal tube-boxes, one to each furnace, and they are returned directly above the furnaces from the back connections to the uptake. These boxes are rectangular, 23½ inches high and 47 inches wide in the clear, with an extreme length of 7 feet 3 inches. They are composed of ½ inch thick iron plates, flanged and single riveted. Their tops and bottoms are the upper and lower tube-plates, and their sides are stayed to each other and to the boiler shell by socket-bolts. The space in the clear between the top of the cylinders containing the furnaces and the bottom of the tube-boxes is 8½ inches.

Each tube-box contains four hundred and fifty vertical water-tubes of seamless brass $\frac{1}{10}$ of an inch thick, expanded on one side and riveted over on the other side of their tube-plates. These tubes are 2 inches in external diameter and 23½ inches high in the clear between their tube-plates. They are arranged in fifteen rows crosswise the boiler, and thirty rows lengthwise the boiler; their axes being in

straight lines, or not staggered. The distance between the axes of the tubes crosswise the boiler is 3 inches, and lengthwise the boiler $2\frac{3}{4}$ inches.

Both tube-boxes discharge into one uptake which, at the top, delivers the gases of combustion into a horizontal sheet-iron flue connecting the uptake of the vertical water-tube boiler with that of the horizontal fire-tube boiler, and from the centre of this flue the chimney, common to both boilers, rises. The uptake has the usual doors for access to the tubes for sweeping, etc.; and the furnace-doors were thoroughly perforated for the admission of air above the incandescent fuel on the grates.

The following are the principal dimensions and proportions of the vertical water-tube boiler:

Diameter of the shell,	10 ft.
Length of the shell, exclusive of the uptake,	9 ft.
Number of furnaces,	2.
Breadth of furnaces,	3 ft.
Length of grates,	6 ft.
Total area of grate surface,	36 sq. ft.
Total number of tubes,	900.
External diameter of tubes,	2 in.
Internal diameter of tubes,	1·80 in.
Length of tubes in clear of tube-plates,	23·50 in.
Total cross area for draught above the bridge-walls,	5·55 sq. ft.
Total cross area for draught through the tubes,	5·55 sq. ft.
Cross area, of the chimney,	12·57 sq. ft.
Diameter of the chimney,	4 ft.
Height of the chimney above the level of the grate-bars,	60 ft.
Heating surface in the two furnaces,	69·03 sq. ft.
Heating surface in the two back connections,	68·00 sq. ft.
Heating surface in the two tube-boxes,	131·10 sq. ft.
Heating surface in the 900 tubes, measured on their inner circumference,	830·55 sq. ft.
Heating surface in the one uptake,	5·32 sq. ft.
Total water heating surface in the boiler,	1,104·00 sq. ft.
Square feet of water heating surface per square foot of grate-surface,	30·67.
Square feet of grate-surface per square foot of cross area above bridge-walls,	6·49.
Square feet of grate-surface per square foot of cross area through tubes,	6·49.
Square feet of grate-surface per square foot of cross area of chimney,	2·87.

Water room to 6 inches above tubes, . . .	310 cu. ft.
Steam room from 6 inches above tubes, . . .	153 cu. ft.
Greatest height of steam room, ...	2·75 ft.
Weight of boiler, exclusive of uptake, chimney, uptake doors, furnace doors and frames, water, grate-bars, bridge-walls, etc., but inclusive of manhole and handhole plates, ...	30,605 pounds.
Weight of uptake, uptake doors and furnace doors, .	1,100 pounds.
Weight of grate-bars and bearers, ...	1,892 pounds.
Weight of cast iron bridge-walls and their brick facing, ...	810 pounds.
Weight of non-radiating cement covering for boiler,	6,000 pounds.
Weight of water in boiler, ...	19,323 pounds.
Total weight of boiler, exclusive of chimney, ready for service, ...	59,730 pounds.

(To be continued.)

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Concluded from Vol. lxxvi, page 246.]

The endeavors to produce matches entirely free from phosphorus, have continued without interruption since the investigation of Wiederhold,† which are of permanent value, and must be regarded as the basis of all subsequent enterprise in this direction. In the opinion of many, they have not yet been so far improved as to be on an equality with phosphorus matches. They are still too hard to strike, diffuse an unpleasant odor, and have no advantage in cheapness. The non-phosphoric matches, however, recently produced on the large scale by G. Kalliwoda,‡ are said to be totally or almost entirely free from these defects. This important problem may therefore be regarded as solved, if prolonged experience confirms the above favorable reports.

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* "Berichte über die Entwickelung der Chemichen industrie während des letzten Jahrzehends.

† Wiederhold, *Jahresber. f. Technol.*, 1861, 622.

‡ Kalliwoda, *Deutsche Industrie Z.*, 1871, 17.

According to C. Liebig, a good mixture, free from phosphorus, may be prepared as follows:—

Sulphuret of antimony,	8 parts.
Chlorate of potash,	16 "
Red lead,	10 "
Bichromate of potash,	1 "
Nitro-mannite,	8 "
Glass,	4 "
Gum arabic,	5 "

Particulars as to the value of this mass are unknown; it cannot be cheap, and the preparation may not be free from danger.

Among the non-phosphoric mixtures, must be included, that suggested by Fleck, containing finely divided sodium diffused in paraffin.

As ingenious as are the methods proposed to counteract the unfavorable attributes of the sodium, this proposal will in all probability never be practically realized, especially as better agents are known.

For blasting charges under water, Fleck's mixture might possibly be applicable, but the spontaneous decomposition which gradually sets in, would be found a difficulty. E. Kopp,* has already called attention to its disadvantages, whilst Springmühl, after a careful examination, and also Jettel, deny that it possesses any practical value.

At the Exhibition, France, Sweden and Austria represented the match trade.

On behalf of France, appeared the *Compagnie Générale des Allumettes Chimique*, formed in the month of October, 1872, and possessing the leading monopoly for the production of matches in the whole of France. For this privilege, it pays to the Government a fixed tax of 16,000,000 francs, as long as the consumption in France does not exceed 40 milliards. Beyond this consumption, there is a progressive duty of 6 centimes per 100 matches. Hence, this company alone, represents the whole of the match trade of France. The former manufacturers, in expectation of the expropriation which they had daily to await, did not exhibit. The importance of this manufacture for France, appears from the following figures.

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* Kopp, *Monit. Scientif.*, 1870, 74.

The number of the (former) match-works in France, large and small, amounts to no fewer than 833. The inland consumption, is on the average, five matches daily per head, or 70 milliards yearly. The company must, therefore, meet the enormous daily demand of 180 millions without maintaining the old 833 works in activity. It has, therefore, decided to concentrate the production in twelve establishments, which will be distributed in the country, according to the need of production and the convenience for procuring the necessary materials. It is of opinion that it will be possible to introduce into each of these works, all those improvements, industrial and sanitary, which science has pointed out as requisite.

Of the 180 millions of matches daily required, 150 millions are of wood, and 30 millions of wax. The former require yearly, 45,000 cubic metres of wood (oak, poplar, aspen, pine and birch), 1200 to 1500 tons of roll-sulphur, and 300 tons of phosphorus (1 ton = 1000 kilos.). The 30 millions of wax-matches, represent a yearly consumption of—

300,000 kilos. spun cotton.
300,000 " stearin.
60 tons of phosphorus.

To this, must be added the consumption of the other articles, such as red-lead, gum, etc., of which the company's report to the jury gives no account.

This daily production of 180 million matches, requires above 6000 workpeople, both men and women. The varied, more or less elegant, pasteboard boxes are manufactured by the company, 3 millions being required daily, requiring a yearly consumption of at least 2500 tons of pasteboard of various qualities. As to the number of work-people engaged in the production of these boxes, the report gives no particulars, but we may conclude from other sources that about 12,000 persons of both sexes will suffice, to whom must further be added those employed in packing and sending off, to the number of at least 200 persons.

The above figures refer merely to the home consumption, but there is also considerable exportation, not merely by sea, but even into other countries of Europe. The French marks, "Roche," "Causemille," "Meiffreu," are in request at La Plata, Buenos Ayres, Japan, Guatemala, Peru, etc. The exportation amounts to the yearly value of 15 mill. francs, and consists exclusively of wax lights and round

wooden matches. The traffic of the Société Générale is therefore as follows:—

Domestic consumption, . .	65,000,000 frs.
Exportation, ...	15,000,000 "
	80,000,000

Which is distributed as follows:—

Duty on consumption, . .	35,000,000 frs.
Duty on exportation, . .	1,800,000 "
Allowance to dealers, . .	13,000,000 "
Cost of production and profit, .	30,200,000 "
	80,000,000 "

Finally, must be remarked that in the show-case of the company Coignet, Père et Fils, exhibit matches with a friction-surface of amorphous phosphorus.

In few countries has the manufacture of matches reached such a development, and is still making such progress, as in Sweden. Swedish matches are known in all civilized countries, and so valued that counterfeits are sold as Swedish. The exportation, which was only 1,114,677 kilos. in 1865, and 2,896,398 kilos. in 1870, rose in 1871, to 4,281,395, and in 1872, to 6,059,601 kilos. The requisite chemicals are imported from England. The works at Jönköping alone produce yearly, matches of the value 1½ millions riksdaler (at 1 mark 14 pf. German), and the production of the remaining twenty-four establishments now in operation, may be of equal value. Besides, there are some manufactories engaged solely with the manufacture of fusee-wire.

The largest establishment at Jönköping, is the property of a joint-stock company. It was founded in 1845, and is driven by four steam-engines, of the joint power of 76 horses. In 1872, there were employed 255 men, 849 women, 105 boys and 141 girls, the two latter groups under eighteen years of age; together, therefore, 1350 persons. Of the workwomen, 688 were only periodically engaged in their own houses, and that with the manufacture of boxes.

The production is constantly increasing, and amounted in 1872 to 128,039,754 matches of different kinds, representing a value of 1,857,249 riksdaler. About four-fifths of the total production are exported. The company has founded a school, a reading-room, baths for the workpeople, and is now erecting cottages for their accomodation. It employs alone as many workpeople as all the rest of the Swedish match works, and paid in 1872, 360,514 riksdaler in wages.

In the sister-kingdom of Norway, the match trade has also taken root, although on a smaller scale. Amongst the countries in which this manufacture was earliest established, and has been remarkably successful, Austria must not be forgotten, although its production is now less extensive than that of Sweden. The exportation of matches, wax-lights, etc., amounts to, in the years—

1870, ...	46,684 kilos.
1871, ...	43,685 "
1872, ...	42,436 "

The decline of the trade is ascribed to heavy local taxation. There are at present 43 large and 79 smaller establishments in operation.

Other Applications of Phosphorus.—Phosphorus is employed not merely in the match trade, but in so many other branches, both in a free state and in numerous compounds, that we cannot undertake their exhaustive description. The scientific chemist uses this element in innumerable investigations, as, *e. g.*, in the preparation of methyl- and ethyl-iodide, which, thanks to the labors of A. W. Hofmann, have become indispensable agents in research, and have found extensive application in chromo-technics. For such purposes, amorphoic phosphorus is often used instead of the ordinary kind, since its reactions are as a rule less violent.

In pharmacy, phosphorus plays also an important part, although exclusively in the shape of one of its oxygen compounds, phosphoric acid. This acid is found to be an excellent medium for introducing into the organism, the iron neccessary for the formation of blood. For this reason, ferric pyrophosphate, which has no inky flavor, and indeed very little perceptible taste, has rapidly become a favorite medicine, and it is used in Grimault's iron-syrup, in Löflund's extract of malt, and in so called "iron-sugar." As a reagent for many substances belonging to the *materia medica*, phosphoric acid is also important. According to Kratschmer and Nowak,* it is the best test for atropin; according to C. Scheibler,† there is no better precipitant, for nearly all organic bases than phospho-tungstic acid, a combination of phosphoric and tungstic acids, equally available for scientific and technological purposes.

Particularly important is the method of Prof. E. N. Horsford, of Cambridge, U. S., for the preparation of bread without yeast, and

* Kratschmer and Norwak, *Vien. Acad. Ber.*, ii, 69.

† Scheibler, *Dingl. Pol. Journ.*, ccix, 141.

consequently without fermentation, by means of phosphoric acid. Liebig * considers this invention "one of the most important and beneficial that have been made within the last ten years." Prof. Horsford, who, during his stay in Vienna, as an Exhibition juror, had the kindness to perform his process in the laboratory of the reporter, proceeds as follows:—White washed bone-ash, (3 parts) are treated with about 2·4 parts of sulphuric acid, from which the small amount of lead present in the commercial acid has been previously precipitated by dilution with 10 parts of water. It is thus converted into the well-known calcium phosphate [$CaH_2(PO_4)_2$], which still contains one-third of the lime in the bones. After removing the gypsum, the liquid, which also contains the magnesia of the bones, is concentrated to the consistence of honey, and when cold is mixed with 1 part of starch of any kind, thus forming when thoroughly kneaded together a crumbly mass, which, on exposure to a gentle heat, yields a white powder. To this is added bicarbonate of soda, in the proportion of 3 parts of the phosphate to 1 of the soda-salt. Dough is now prepared with flour, mixed with salt, and with the above-mentioned baking powder, worked up well together and baked in the usual manner.

The carbonic acid thus liberated makes the bread light and porous, so that in this respect it differs, if at all, advantageously from that produced with yeast. If bicarbonate of potassa is used instead of the soda-salt, the bread has a better flavor, and this procedure would be the more rational, since the greater part of the potash is withdrawn from the flour in the separation of the bran. Heretofore, however, the high price of the potash-salt, stands in the way of this improvement. Leibig, however, proposes to substitute a mixture of the bicarbonate of soda, and chloride of potassium in the proportion of about 2 to 1 for the bicarbonate of potassa.

The advantage of a process so easily executed in every household, and the beneficial effects of this well-flavored bread upon digestion are so evident, that it would be superfluous to enter upon any detailed explanation. We may mention, however, that for armies in the field, the value of this bread must be incalculable, as it is peculiarly adapted to serve for a time as a substitute for animal food. In America, it is already produced in large quantities, and has become a substance of daily consumption. In the recent war it proved very useful. It is evidently possible to incorporate with this bread, by

* Liebig, *Ann. Chem. Pharm.*, cxlix, 37, *Wagner Jahresber.*, 1869, 470.

additions suited to circumstances, all the constituents of blood in the necessary proportion.*

We may finally mention that phosphorus, notably modifies the properties of metals with which it combines directly, and in the case of such as are strongly electro-positive even with the development of fire. The circumstance has met with technological applications, especially in the case of copper, which, by the addition 1·2 to 1·5 per cent. of phosphorus (phosphor-bronze), becomes harder, tougher, more fluid on fusion, and resists external influences better, *e. g.*, the action of sea-water. A plate of this bronze, thus exposed for six months, lost only 1·158 per cent. of its weight, whilst a plate of the best English copper of equal size, lost in the same time 3·058 per cent.

In the works of the Stephenson Tube Company, at Birmingham, phosphorus-bronze has been produced on the large scale since 1865, and is used for tubes, barrels for fire-arms of all kinds, cylinders for calico-printing, etc.

Larger proportions of phosphorus, render copper white and perfectly brittle. What is the exact part which small quantities of phosphorus may play when alloyed with copper is not quite clear. It may, possibly, as Dumas supposes, act principally upon the oxides mixed with the copper, and which, when converted into phosphides, may contribute themselves in the mass, thus rendering it harder, tougher, and more elastic.

The phosphor-bronze, from the works of G. Höpner & Co., at Iserlohn, is already extensively used for the bearings of axles, for gun-barrels, plating, weights, etc. (See the paper on "Copper," in a subsequent part of this report.)

If phosphate of copper, obtained by precipitating sulphate of copper with the phosphate of soda, is mixed with charcoal and exposed to a strong red heat, a white brittle copper phosphide is obtained, very rich in phosphorus, by the aid of which alloys of any desired composition can be most advantageously obtained.

Phosphates have been experimentally used in the glass manufacture, but without any marked benefit. The glass takes a yellow color.†

* See "Theory and Art of Bread-Making: A New Process without the Use of Ferment," by Prof. E. N. Horsford.

† Pelouze, *Ann. Chim. Phys.*, (4), v, 465.

NOTE ON THE TAPER OF CONNECTING-RODS.

By William D. Marks,
Whitney Professor of Dynamical Engineering, University of Penn'a.

In a recent work on the steam engine,* the writer made the following remark:

"It is customary to make round connecting-rods with a taper of about one-eighth of an inch per foot, from the centre to the necks, which should be of the calculated diameter. Experiment does not show an increased strength from a tapering form."

Passed Assistant Engineer C. H. Manning,† in a pleasant correspondence with the writer, differed from him, deeming it the better method to taper connecting-rods from the crank-pin end to the cross-head end, as "experience had shown that connecting-rods usually failed at the crank-pin."

Led by this remark to make a more thorough investigation into the stress upon connecting-rods due to their own inertia, than he had before deemed necessary, the writer submits the results, hoping they may be of interest to engineers engaged in the designing of mechanism.

The connecting-rod, if of *wrought-iron*, must be considered either, 1st, as a short column, tending to rupture by crushing, or 2d, as a long column, tending to rupture by buckling. The tendency to fail in tension, can be neglected as being much less than in the two cases mentioned.

In the first case it is obvious that tapering will not add to its strength, if we neglect the stress due to its inertia and weight.

In the second case, theoretically, if we disregard the stress in flexure due to the inertia and weight of the connecting-rod, the increase in its diameter will be a maximum at its centre. (See "Weisbach's Mechanics of Engineering," Sec. iv, Art. 267.)

The connecting-rod, if of *steel*, may be considered, 1st, as a tension-rod, tending to fail in tension, or 2d, as a long column, tending to rupture by buckling. The ability of steel to withstand a much

* The "Relative Proportions of the Steam Engine."

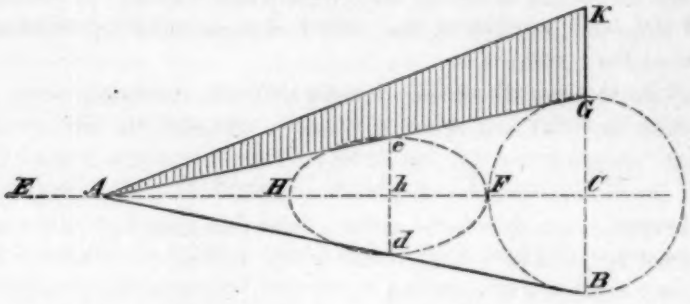
† Instructor in steam engineering, U. S. Naval Academy, Annapolis, Md.

greater stress in compression than in tension, avoids the necessity of considering it as a short column, failing by crushing. In both cases the inertia and weight of the rod are disregarded.

These are the general conditions which have controlled the mechanical engineer in the consideration of the proportions of wrought-iron or steel connecting-rods. In addition, it has been customary in order to meet an unknown stress in flexure, due to the inertia of the rod, to increase the diameter of the rod at the middle, or latterly to give an increased diameter at the crank-pin, and taper from this to the smallest dimension of the rod at the necks or neck, this increase being purely empirical.

Prof. R. H. Thurston, of the Stevens Institute of Technology, in a personal letter, October 31st, 1878, says: "Where iron and steel

FIG. 1.



are used, the figures adopted as constants must vary greatly, especially with steel. The value of E (modulus of elasticity) varies *enormously*," with which opinion the writer agrees perfectly, only regretting that the very basis of all correct calculations is thus taken from us, and we are forced to be contented with results which have a reasonable probability of correctness, if we assume average values for the safe stresses per square inch, and the moduli of elasticity of the material with which we are dealing.

If a straight line, $A\,B$, Fig. 1, have its extremities A and B respectively caused to move reciprocally upon the straight line $A\,E\,H$ and in the perimeter of the circle $B\,F\,G$, any point upon the line $A\,B$ as d will trace an ellipse as $d\,H\,e\,F$.

If, now, we let the length of the line $A\,B = l$; the radius $C\,B$ of the circle $= r$; the variable distance of the point d from the point

$A = A\,d = l_1$; we have the semi-major-axis of this ellipse $h\,F = h\,H = r$, and the semi-minor-axis $h\,d = h\,e = \frac{l_1}{l}r$, and the radius of curvature of the osculatory circle at the vertex d of the semi-minor-axis,

$$= R = \frac{l}{l_1}r. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The maximum resistance due to its inertia of any small mass m at the end B of the rod $A\,B$, to motion in the direction $B\,C$, is equal to its centrifugal force

$$= c = \frac{m\,v^2}{r}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which v = the linear velocity of the point B in feet per second.

For a demonstration of this, refer to a paper by F. A. P. Barnard, Transactions of the American Institute.

Observing now that in the position shown in the figure, every point on the line $A\,B$ as d is moving with a velocity v in an arc of an osculatory circle, whose radius is $R = \frac{l}{l_1}r$, equation (1), we have the means of determining the resistance due to the inertia of each element of mass m.

For the point d it would be

$$\frac{m\,v^2}{R} = \frac{m\,l_1\,v^2}{l\,r}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For the point A, since $l_1 = 0$, $R = \infty$, and the resistance of a mass m would be $= 0$. We thus see, equation (3) that the resistance of each element of mass due to its inertia to motion in a direction at right angles to $E\,A\,C$, is directly proportional to its distance $= l'$ from the point A.

If, now, for the line $A\,B$ we substitute a rod of uniform cross-section $= F$, we have

$$m = \frac{F\,d\,l_1\,\gamma}{g}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

in which γ = weight per cubic unit, and $g = 32{\cdot}2$ feet per second, F being taken in square units.

Substituting this value of m in equation (3), and integrating between the limits $l_1 = 0$ and $= l$, we have, denoting the whole resistance of the rod $A\,B$ by P,

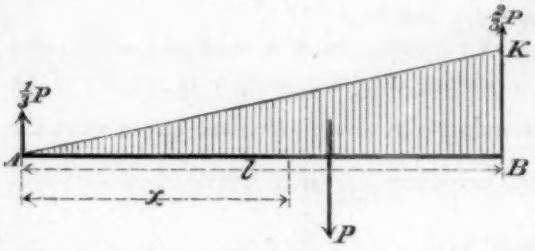
$$P = \int_0^l \frac{F\gamma v^2}{g\,l\,r}\, l_1\, d\,l_1 = \frac{F\gamma v^2}{2\,g\,r}\, l,$$

or since the weight of the rod $= G = F\gamma\, l$,

$$P = \frac{G\,v^2}{2\,g\,r}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

And since this load upon the rod due to the resistance of its own inertia increases uniformly from the end A to the end B, the rod can, with sufficient approximation, be supposed in the condition of a horizontal beam loaded with a triangularly-shaped load, as shown, Fig. 2, in the cross-hatched portion $A\,K\,B$.

Fig. 2.



For a vertical engine, we can neglect the weight of the connecting-rod, considering only the stress due to its inertia.

For the moment of flexure of any cross-section at a distance x from the extremity A, we have, letting c = the load per unit of length at the point K,

$$\tfrac{1}{3}\,P\,x - \tfrac{1}{6}\,\frac{c}{l}\,x^3 = \tfrac{1}{3}\,P\left(x - \frac{x^3}{l^2}\right), \quad . \quad . \quad . \quad . \quad (6)$$

which becomes a maximum for $x = l\sqrt{\tfrac{1}{3}} = 0{\cdot}578\ l$, and at which point, therefore, the maximum cross-section of the connecting-rod should be placed.

In horizontal engines it is necessary to take into consideration the weight of the rod, as well as its inertia; the weight of the rod may be regarded as a uniformly distributed load, always acting in one direction.

For the cross-section, at a distance x from the extremity A, the moment of flexure is letting G = whole weight of rod $= \gamma\, l$

$$(\tfrac{1}{3}\,P + \tfrac{1}{2}\,G)\,x - \left(r\,\frac{x^2}{2} + \tfrac{1}{6}\,\frac{c}{l}\,x^3\right) =$$

$$(\tfrac{1}{3}\,P + \tfrac{1}{2}\,G)\,x - \frac{G}{2\,l}\,x^2 - \frac{P}{3\,l^2}\,x^3 \; . \quad . \quad . \quad . \quad (7)$$

which is a maximum for

$$x = -\frac{G\,l}{2\,P} \pm l\,\sqrt{\frac{1}{3} + \frac{G}{2\,P} + \frac{G^2}{4\,P^2}} \; . \quad . \quad . \quad . \quad (8)$$

But we have from equation (5),

$\frac{G}{2\,P} = \frac{g\,r}{v^2}$, in which g = acceleration of gravity, v = the linear velocity of the crank-pin, B, in feet per second, and r = the radius of the crank in feet. Substituting this value in equation (8), we have,

$$x = l\left\{-\frac{g\,r}{v^2} \pm \sqrt{\frac{1}{3} + \frac{g\,r}{v^2} + \left(\frac{g\,r}{v^2}\right)^2}\right. \quad . \quad . \quad . \quad (9)$$

which shows that as the velocity of the crank-pin increases, the value of x approaches more nearly to $l\sqrt{\frac{1}{3}} = 0{\cdot}578\,l$, but can never quite equal it.

Referring to equation (7), and taking P = zero, we find the maximum value of $x = \frac{l}{2} = 0{\cdot}5\,l$.

We thus see that the greatest moment of flexure of any connecting-rod lies between the limits $0{\cdot}5\,l$ and $0{\cdot}578\,l$, measured from the point A.

It is of interest further to note, that the crank-pin takes one-half the stress due to the weight of the rod, and two-thirds of the stress due to the inertia of the rod.

The end, A, takes one-third of the stress due to the inertia of the rod, alternately increasing and decreasing the stress upon the guides to this amount and one-half the stress due to its weight.

In engines having a large number of revolutions per minute, P becomes worthy of notice. In slow-moving engines it is very small, and may be neglected.

From these considerations, the writer is of the opinion that the failure of connecting-rods, at the neck nearest the crank-pin, *if they are properly proportioned*, is probably due more to the crank-pins being

out of truth, rather than to the weight or inertia of the rods themselves.

He further takes this opportunity to state, that in a properly proportioned engine of any assumed horse-power, the *only* method of diminishing the weight of the moving parts, is to increase the number of strokes—lengthening the stroke will not do it.

December 7th, 1878.

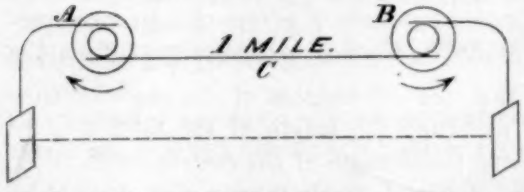
ON THE TRANSMISSION OF POWER BY MEANS OF ELECTRICITY.

By Profs. Elihu Thomson and Edwin J. Houston.

The statements recently made as to the size and cost of the cable that would be needed to convey the power of Niagara Falls to a distance of several hundred miles by electricity, have induced the authors to write the present paper, in the hope that it may throw light upon this interesting subject.

As an example of some of the statements alluded to, we may cite the following, viz.: That made by a certain electrician, who asserts that the thickness of the cable required to convey the current that could be produced by the power of Niagara, would require more copper than exists in the enormous deposits in the region of Lake Superior. Another statement estimates the cost of the cable at about $60 per lineal foot.

Fig. 1.



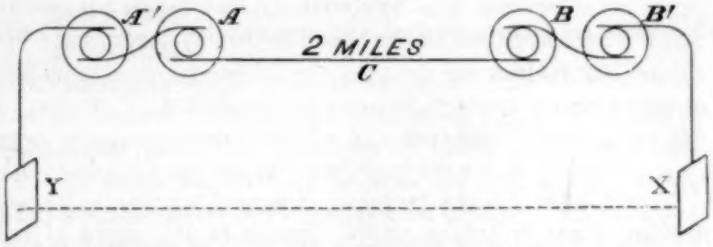
As a matter of fact, however, the thickness of the cable required to convey such power is of no particular moment. Indeed, it is possible, should it be deemed desirable, to convey the total power of Niagara, *a distance of* 500 *miles or more, by a copper cable not exceeding one-half of an inch in thickness.* This, however, is an extreme case, and the exigencies of practical working would not require such restrictions as to size.

The following considerations will elucidate this matter. Suppose two machines connected by a cable, of say 1 mile in length. One of these machines, as, for example, *A*, Fig. 1, is producing current by

the expenditure of power; the other machine, B, used as an electrical motor, is producing power, by the current transmitted to it from A, by the cable C. The other terminals, x and y, are either put to earth, or connected by a separate conductor.

Let us suppose that the electromotive force of the current which flows is unity. Since by the revolution of B, a counter-electromotive force is produced to that of A, the electromotive force of the current that flows is manifestly the difference of the two. Let the resistance of A and B together, be equal to unity, and that of the mile of cable and connections between them, the ·01 of this unit. Then the current which flows will be $C = \frac{E}{R} = \frac{1}{1 \cdot 01}$. If now an additional machine, A', Fig. 2, and an additional motor, B', and an additional mile of cable, be introduced into the above circuit, the electromotive

Fig. 2.



force will be doubled, and the resistances will be doubled, the current strength remaining the same as $C = \frac{E}{R} = \frac{1+1}{1 \cdot 01 + 1 \cdot 01} = \frac{2}{2 \cdot 02}$. Here it will be seen that the introduction of the two additional machines, A' B', has permitted the length of the cable c to be doubled, without increasing the strength of the current which flows, and yet allowing the expenditure of double the power at A A', and a double recovery at B B' of power, *or, in other words, a double transmission of power, without increase of current.* Increase, now, the number of machines at A to say one thousand, and of those at B in like proportion, and the distance between them, or the length of the cable, one thousand, or in the case we have supposed, make it one thousand miles, its diameter remaining the same. Then although the same current will flow, yet *we have a thousand times the expenditure of power at one end of the cable, and a thousand-fold recovery at the*

other end, without increase of current. And the same would be true for any other proportion.

Since the electromotive force is increased in proportion to the increase of power transmission, the insulation of the cable and machines would require to be proportionally increased.

As an example, it may be mentioned that a dynamo-electric machine used for the purpose of A in the figure, may have a resistance of say 40 ohms, and produce an electromotive force of say 400 volts. Such a machine might require from three to five horse-power when used in connection with a suitable motor B, for recovery of the power transmitted.

If the resistance of the motor B, be say 60 ohms, and the cable transmitting the currents a distance of one mile, be one ohm, then the current $C = \frac{400}{60+40+1} = \frac{400}{101}$. If now, one thousand machines and one thousand motors, and a thousand miles of cable, each of the same relative resistances be used, the current $C = \frac{1000 \times 400}{1000 \times 101}$, which has manifestly the same value as before. If our supposition of the power used to drive one machine be correct, then from three to five thousand horse-power would be expended in driving the machines, and possibly about fifty per cent. of this amount recovered. Then we have from 1500 to 2000 horse-power conveyed a distance of 1000 miles. What diameter of copper cable will be required for such transmission? Since this cable is supposed to have the resistance of one ohm to the mile, calculation would place the requisite thickness at about $\frac{1}{4}$ inch. If, however, the distance be only 500 miles, then the resistance per mile may be doubled, or the section of the cable be decreased one-half, or its diameter will be less than the $\frac{1}{5}$ inch.

For the consumption of 1,000,000 horse-power, a cable of about 3 inches in diameter would suffice under the same conditions. However, by producing a much higher electromotive force, the section of the cable could be proportionally reduced, until the theoretical estimates, which we have given in the first part of this paper, might be fulfilled. The enormous electromotive force required in the above calculation, would, however, necessitate such perfect insulation of the cable, that the practical limits might soon be reached. The amount of power required to be conveyed in any one direction, would, of course, be dependent upon the uses that could be found for it; and it is hardly

conceivable that any one locality could advantageously use the enormous supposed power we have referred to.

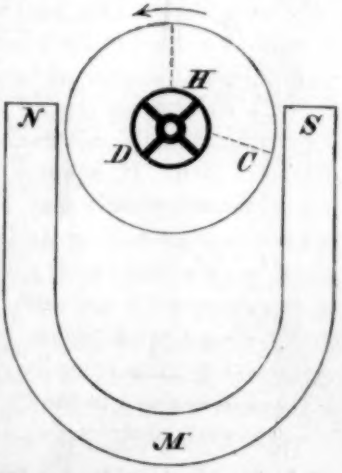
Stripped of its theoretical considerations, the important fact still remains, that with a cable of very limited size, an enormous quantity of power may be transferred to considerable distances. The burning of coal in the mines, and the conveyance of the power generated by the flow of rivers, may therefore be regarded as practicable, always, however, remembering that a loss of about 50 per cent. will be almost unavoidable.

It may be mentioned that Dr. C. W. Siemens, and Sir William Thomson, have recently made statements that are in general accordance with the views here expressed.

A CURIOUS THERMO-MAGNETIC MOTOR.

By Profs. Edwin J. Houston and Elihu Thomson.

During investigations by the authors, concerning the increase in the coercitive force of steel by changes of temperature, the following curious thermo-magnetic motor was devised. This motor, though devoid of practical value, will, no doubt, be of sufficient scientific interest to warrant a short description.



In the figure, a disc or ring of thin steel, *D*, is mounted on an axis, so as to be quite free to move. The edges of the wheel are placed opposite the poles *H* and *S*, of a magnet. In this position the wheel of course becomes magnetized by induction.

If now, any section of the wheel, as *H*, be sufficiently heated, the disc will move in the direction shown by the arrow. The cause of this motion is as follows: The section *H*, when heated, has its coercitive force thereby increased, and being less powerfully magnetized by the induction of the pole *S*, than the portion *C*, immediately adjacent to it, the attraction exerted by the pole *S*

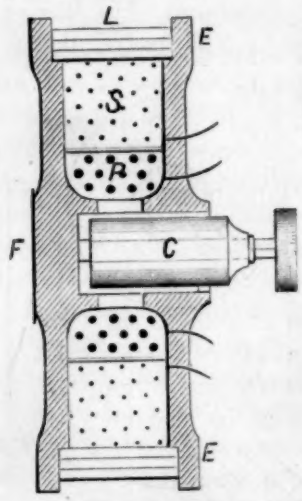
on the latter portion is thereby sufficient to cause a movement of the disc in the direction shown by the arrow. If a constant source of heat be placed at *H*, a slow rotation in the direction shown is maintained.

To ensure success, the disc must be sufficiently thin as to prevent its acquiring a uniform temperature. If the source of heat be at the same time applied at diametrically opposite portions of the disc, as at *H* and *D*, adjacent to the poles, the same effect will be produced. Since the amount of heat expended in producing motion of the disc is so enormous when compared with the force developed, it will be readily understood that this motor is of no value as such, but must be regarded as an interesting example of the interconvertibility of force.

INDUCTION APPARATUS FOR REVERSED CURRENTS.

By Profs. Elihu Thomson and Edwin J. Houston.

The following apparatus was devised by the authors for the purpose of obtaining induced reversed currents for use in electric illumination. These currents we use with a vibrating lamp, somewhat similar in construction to a lamp, a description of which has already been published.



Our method of operation is as follows: A reversed primary current is caused to induce reversed secondary currents in secondary coils provided therefor. These secondary currents are caused to give vibrations to carbon electrodes, and thereby at the same time produce a partial arc between them. With sufficient strength of primary current, a considerable number of secondary currents are obtained, each of which is able to operate one of our vibrating lamps.

The use of a vibrating lamp admits of a wider ange in the size of the carbons employed. When a light of very moderate intensity is desired, the carbons are made of very small size, and are placed in a closed glass vessel for protection from the atmosphere. To moderate the brilliancy, opalescent glass is used.

To obtain the highest efficiency of inductive action from a set of primary coils, the following form of induction of coil was devised: The primary coil *P*, surrounding the core *C*, is provided with a secondary coil *S*, adjacent to it. The ends *E* and *F*, of the bobbin, are made of disks of iron concentric with the core *C*, and slit from centre to circumference. The outer extremities of these disks are connected by wires or sheets of iron *L*, to one another, forming, in this manner, an induction coil encased in iron, or one whose core has its north and south extremities magnetically connected. The strength of the current developed in the secondary coil is greatest when the core *C*, which is movable, is inserted so that both of its extremities are in contact with *E* and *F*. By withdrawing this core, the currents in the secondary coil may be weakened to almost any desired extent. This coil is best adapted to the use of primary currents whose direction is constantly changing. All the wire being completely surrounded by iron whose direction of magnetic polarization is rapidly changed, the highest inductive effect is thereby produced in the secondary coil.

The variations in the intensity of the induced currents will, of course, be followed by variations in the intensity of the light emitted by the lamp. The movement of the core may, therefore, be made to increase or decrease the intensity of the light.

THE EFFECT OF CONTINUED AND PROGRESSIVELY INCREASING STRAIN UPON IRON.

By Charles Huston.

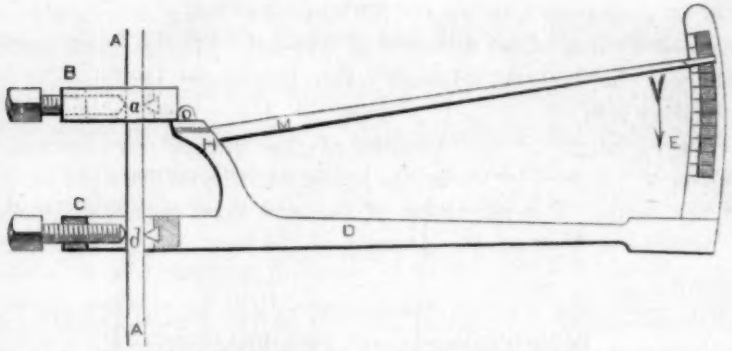
I have observed repeatedly when a piece of iron was subjected to heavy strain in the testing machine, sufficient to produce more or less elongation, that if the strain was kept up for some time, say 24 hours or more, the iron underwent a change in its character. This change was shown in the fact that although an increase of elongation had been produced with each addition of 1000 lbs. to the square inch when applied without much interval, after the lapse of 24 hours it required 5000 lbs. to develop further elongation.

In order to investigate this subject with some system, I took five pieces from the same plate of bridge iron designated in the following table by Nos. 188, 189, 194, 195, 196. To enable the reader fully

to understand, however, the details of the experiments, it is necessary to explain the apparatus used. The testing machine used was made by the E. & T. Fairbanks Co., the strain being produced by the screw, which I prefer because the power is positive, and whatever strain is developed, can be maintained for any length of time without the variation liable to occur from the leaking or other defects of the pump. The apparatus used for measuring the elasticity and permanent set, was devised by myself, and now under the control of the E. & T. Fairbanks Co., is shown in the accompanying figure.

A, Figs. 1 and 2, represents the test-piece supposed to be fastened in the testing machine; *B* is a clamp which is attached to the test-piece between a knife-edge and a steel-pointed screw, thus establishing a fixed point at *a* on the test-piece; *C* is another clamp similar to *B*,

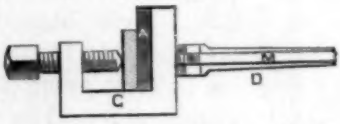
FIG. 1



and establishing another fixed point on the test-piece at *b*; the clamp *C*, however, carries a long arm *D*, which has at its outer end a graduated arc divided into inches, and each inch divided into 25 parts. Attached to the clamp *C* is the post *H*, which rises underneath the clamp *B* as near as possible, without contact; resting on this post is the indicator *M*, with a knife-edge bearing, Figs. 1 and 3, and measuring $\frac{1}{4}$ inch in length at the short end, and 10 inches at the long end, the short end resting in contact with the under side of the clamp *B*. When everything is properly adjusted, the length of the test-piece embraced between the two clamps should be just 2 inches; it is manifest, therefore, that any increase or decrease of distances between the points *a* and *b*, will cause the end of the indicator to fall or rise on the scale *E*, and with the measurements above, give an elongation of the test-piece between *a* and *b*, of $\frac{1}{1000}$ of an inch, will cause the indicator to fall one degree on the scale.

When using this little apparatus, we shall find the moment we put any strain upon the test-piece it lengthens, but if the load is not made too great, the piece will contract to its original length on the removal of the load; this property I have named the *elasticity*.* When, however, the indicator fails to return to its original position, it is an evidence that there has been a disturbance of the particles of the iron, and we then have two measurements: 1, the *degree of elasticity* as above, and, in addition, the next, 2, *degree of permanent set*, measured by the number of degrees the indicator fails to return after the load has been removed.

Fig. 2.



With this explanation, therefore, I return to the five test-pieces named above.

These were placed in the machine, and a record of both elasticity and permanent set kept with each increase of 1000 lbs. to the square inch of load, beginning at 10,000 lbs., but as the record below the point of permanent set is not of practical value, I have prepared the accompanying table and strain diagram, beginning at 27,000 lbs., the lowest point at which any of the specimens took permanent set. In the strain diagram there is no account taken of the *elasticity*, but only of the *permanent set*.

In specimen No. 188, as will be observed, permanent set took place at 31,000 lbs., and the load was increased 1000 lbs. at a time, without interruption, until the piece was broken; in the strain diagram, however, the elongation is not carried beyond ·030, that being the extent to which the little apparatus could measure; the total elongation, however, together with the tensile strength and contraction of area at point of fracture, are given at the foot of the table.

Fig. 3.

The next specimen, No. 196, took permanent set at 27,000 lbs., and was then kept at that strain for 24 hours; 1000 lbs. additional were then added, without increased permanent set; another 1000 lbs. were then added, and the permanent set was increased as before. This head (29,000 lbs.) was then maintained for 24 hours, at the end of which time another 1000 lbs. were added, with no change, but when the next 1000 lbs. were put on, it again elongated, and then

* The inherent property in bodies, by which they recover their former figure or dimensions after the removal of the external pressure or altering force.—Webster.

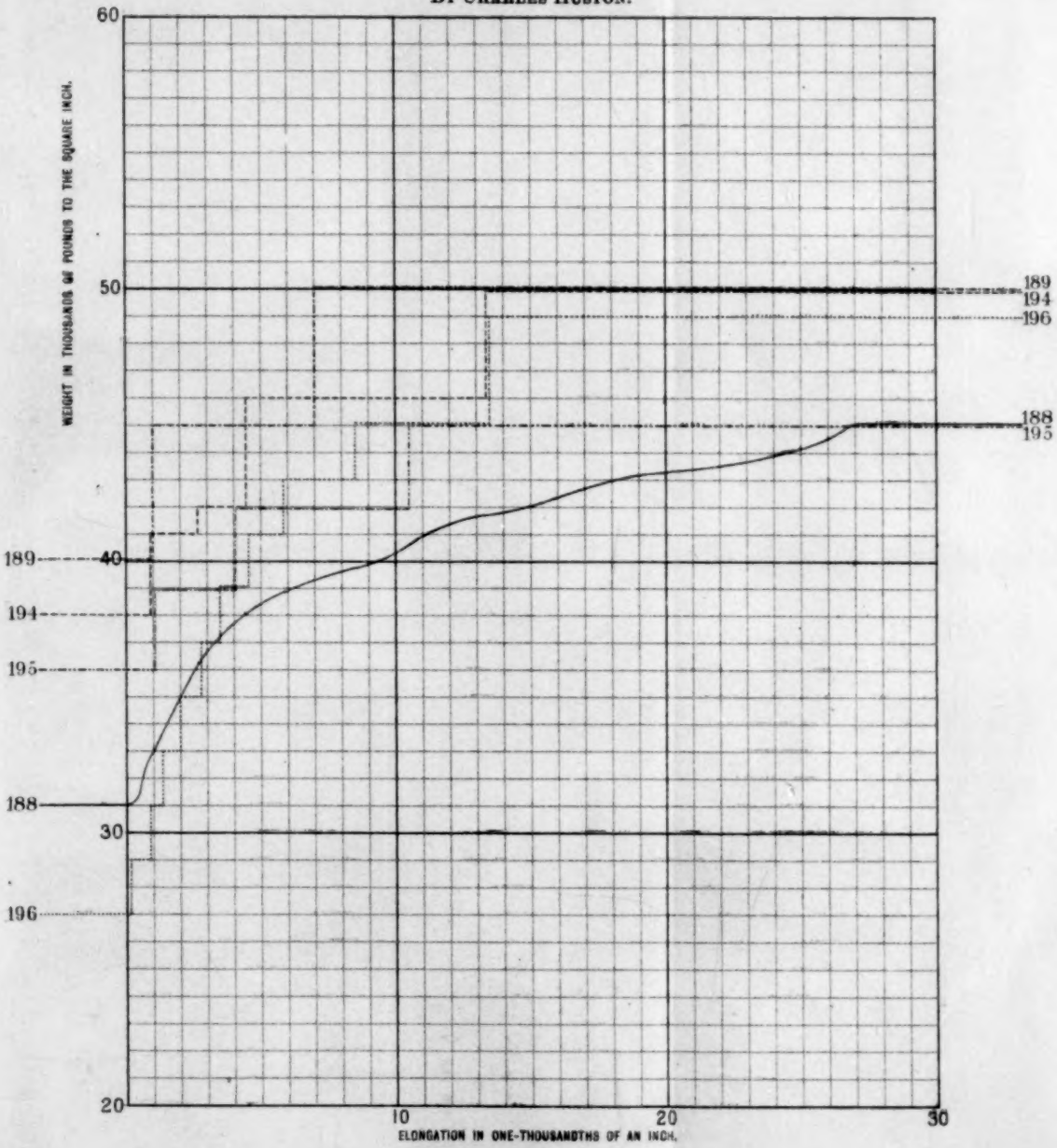
TABLE SHOWING THE EFFECT OF CONTINUED AND PROGRESSIVELY INCREASING STRAIN UPON IRON.

Load to Square Inch.	Test Piece No. 188.		Test Piece No. 196.		Test Piece No. 195.		Test Piece No. 194.		Test Piece No. 189.	
	Elasticity.	Perm. Set.	Elasticity.	Perm. Set.	Elasticity.	Perm. Set.	Elasticity.	Perm. Set.	Elasticity.	Perm. Set.
27,000	·00105	None.	* ·0012	·0001	·00145	None.	·0008	None.	·00105	None.
28,000	·0011	"	·0013	·0001	·00155	"	·00085	"	·0011	"
29,000	·00115	"	* ·0014	·0009	·00165	"	·0009	"	·00115	"
30,000	·0012	"	·0015	·0009	* ·00175	"	* ·00095	"	* ·0012	"
31,000	·0012	·0005	* ·00155	·00125	·0018	"	·001	"	·00125	"
32,000	·0012	·0007	·0016	·00125	·00185	"	·00105	"	·0013	"
33,000	·0012	·0009	* ·00165	·002	* ·0019	"	·0011	"	·00135	"
34,000	·0012	·0015	·0017	·002	·00195	"	* ·00115	"	·0014	"
35,000	·0012	·002	* ·00175	·00275	·00195	"	·0012	"	* ·00145	"
36,000	·0012	·0025	·0018	·00275	* ·002	·00115	·00125	"	·00155	"
37,000	·0012	·003	* ·0018	·0035	·00205	·00115	·00135	"	·0016	"
38,000	·0012	·0045	·00185	·0035	·0021	·00115	* ·00145	·0009	·00165	"
39,000	·00125	·006	* ·00185	·0047	* ·00215	·00415	·0015	·0009	·00175	"
40,000	·00125	·0095	·00185	·0047	·0022	·00415	·00155	·0009	* ·0018	·00105
41,000	·0015	·011	* ·00185	·00595	·00225	·00415	·00165	·00265	·00185	·00105
42,000	·0015	·016	·00185	·00595	* ·00225	·0106	* ·00185	·0044	·0019	·00105
43,000	·00175	·0185	* ·00185	·00845	·00235	·0106	·0019	·0044	·00195	·00105
44,000	·00175	·0255	·00185	·00845	·0024	·0106	·00195	·0044	·002	.00105
45,000	·002	·027	* ·0019	·0134	* ·0025	·022	·002	·0044	* ·002	·007
46,000	.....	.....	·0019	·0134	·0026	·022	* ·0021	·0134	·00205	·007
47,000	.....	.....	* ·00195	0134	·0027	·022	·0022	·0134	·0021	·007
48,000	.....	.....	·002	·0134	.....	.....	·00225	·0134	·0021	·007
49,000	.....	.....	.....	.....	.....	.....	·0023	.0134	·00215	·007
	Area, ·899 × ·365 = ·2953. T. S. to sq. inch 61,293 lbs. Elongation in 2″ = ½″ = 25 per cent. Contraction of Area = 25 per cent.		Area, ·830 × ·364 = ·3021. T. S. to sq. inch 59,900 lbs. Elongation in 2″ = 15·6 per cent. Contraction of Area = 20 per cent.		Area ·829 × ·361 = ·2993. T. S. to sq. inch 58,800 lbs. Elongation in 2″ = 15·6 per cent. Contraction of Area = 18·3 per cent.		Area ·829 × ·361 = ·2993. T. S. to sq. inch 60,000 lbs. Elongation in 2″ = 13 per cent. Broke at flaw outside of the 2″.		Area ·807 × ·362 = ·2921. T. S. to sq. inch 66,415 lbs. Elongation 19 per cent. Contraction of Area = 20 per cent.	

* Load carried 24 hours.

THE EFFECT OF CONTINUOUS AND PROGRESSINGLY INCREASING STRAIN UPON IRON.

By Charles Huston.



THE JANNEY CAR-COUPLER.

From the Secretary's Report at the meeting of the Franklin Institute, Dec. 18th, 1878.

Large sums of money and a great amount of time have been spent in endeavors to devise a perfect system of connecting the cars of passenger railway trains, but the requirements are so numerous, and the difficulties to be overcome so great, that much the larger number of the efforts in this direction have proved failures.

The car-coupler invented by Mr. E. H. Janney, together with his automatic and double-acting compressing device, as applied to equalizing side-buffers, as shown in the accompanying figure, constitute a most complete system for this purpose, and one which is meeting with much favor with some of our leading railroads.

FIG. 1.

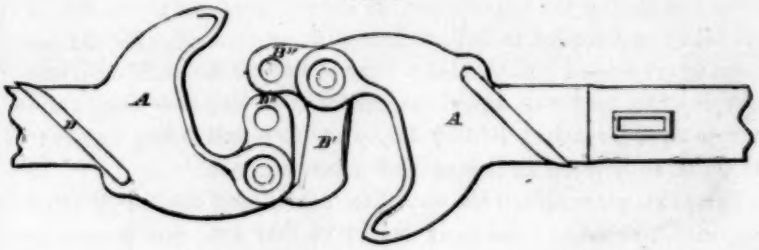


Fig. 1 is a top view of two couplers, represented as approaching each other for coupling.

In Fig. 2 two couplers are united; one in section, to show the internal arrangement of the parts.

Fig. 3 represents the knuckle, *B*, which, when in proper position, serves to hold the two couplers together.

Fig. 4 represents a plan of the platform, with the coupler, compressing device and side-buffers attached.

Fig. 5 represents a sectional and Fig. 6 an end view of same.

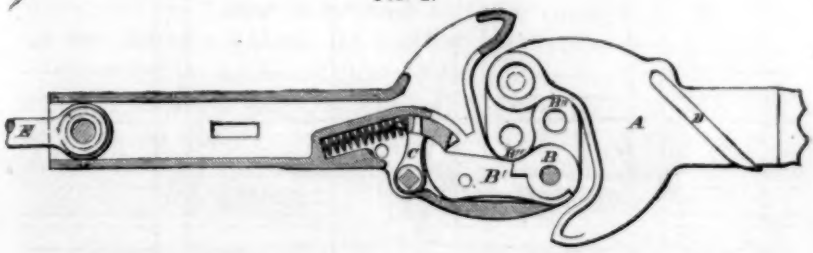
The knuckle, *B*, represents a pinion with two teeth, *B'* and *B''* (the other teeth of the series being dispensed with) and the drawhead, *A*, and tooth or nose, *B''*, of the other coupler representing the rack. When the couplers are forced together, the teeth engage each other, the hub revolves, and the long tooth, *B'* is carried around into a locking position; the catch, *C*, being forced back by the

circular end of the tooth, B', in passing, after which the catch is returned to its locking position by the catch-spring.

The action in coupling is similar to a pinion, being revolved by the rack, or, when both knuckles are thrown open, to two pinions passing each other and turning on their axes.

The uncoupling is effected by throwing over the platform lever, M, Fig. 6, which in turn forces around the coupler-lever, D, Fig. 2, and catch C back, so as to allow the tooth, B', to revolve outward.

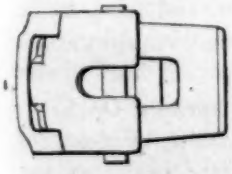
Fig. 2.



It will be observed that the two couplers, when united, form a perfect and closely-fitting knuckle-joint, and therefore give perfect freedom in curving, without either lateral or longitudinal lost motion. It will also be noticed that the guard-arms extend beyond the head of the opposite coupler, and thus absolutely prevent accidental uncoupling; while, from their shape, they serve to guide the parts into coupling position as they approach each other.

The buffers, F, Figs. 5 and 6, are attached at their rear ends to an equalizing bar, which makes the compression on each buffer-head, equal under all circumstances.

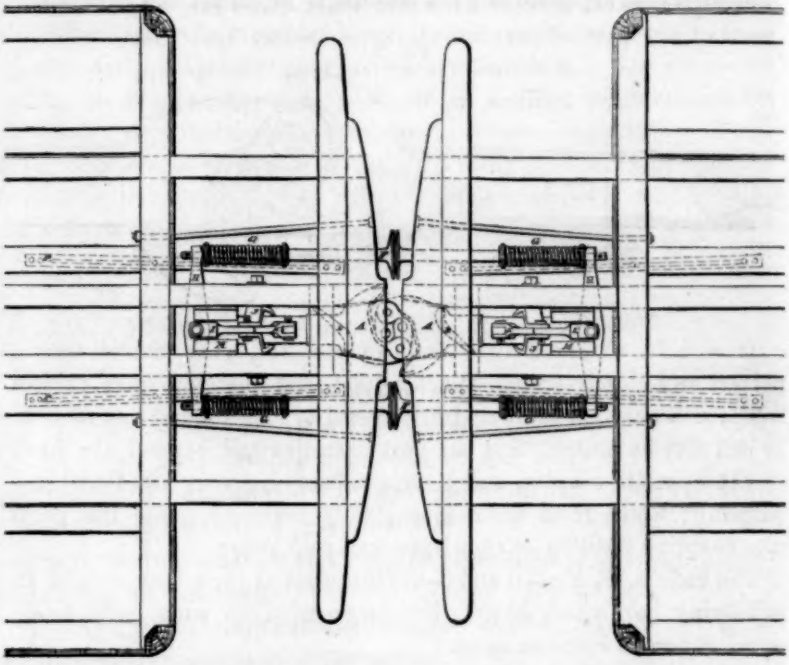
Fig. 3.



The equalizing-bar, H, is pivoted, at its centre, to the clevis, I, which in turn is pivoted to the yoke-lever, J, and the yoke-lever connected to the horn, L, by means of the clevis, K. The yoke-lever is pivoted midway between the pivot point of clevis I, and its point of contact with the lower end of horn L, below the coupler; hence its movement must be in the arc of a circle. It will be seen that the clevis, I, is pivoted at almost double the distance from the yoke-lever pivot point, as the clevis, K, and therefore, in a forward movement, would travel nearly twice the distance.

The object of this combination is to increase the compression on each buffer-head as the cars move from their normal position in either direction, and to keep them in close contact, under all circumstances, without the use of heavy buffer-springs, or extending the buffers out so far before a coupling is effected, both of which methods are objectionable, and do not accomplish the object sought. The operation is as follows:

FIG. 4.



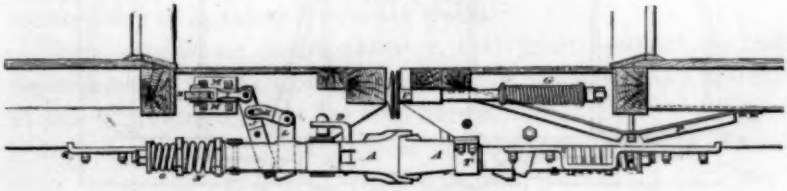
The buffer-heads stand out, before a coupling is effected, about 1 inch beyond the inside face of the coupler-knuckle, and have to be forced back that distance to make the coupling, which requires about 1000 lbs. pressure on each buffer-head.

When the train is started, the coupler-draft springs, *O* and *N*, yield, allowing the coupler to be drawn out, and with it, by means of the intermediate connection heretofore described, the equalizer, but at an increase motion over the coupler in proportion to the difference in the distance between the pivot points of clevises *I* and *K* from the pivot centre of the yoke-lever, which increase is provided for by the compression of the buffer-springs, *G*.

It will be understood, therefore, that if the compression at the start is equal to 1 inch, and the movement of the equalizer over the coupler is at the rate of nearly 2 to 1, when the coupler has traveled 2 ins., the equalizer will have traveled nearly 4 ins., thereby increasing the compression on the buffer-springs, *G*, 2 inches, making 3 inches in all.

The same is true in buffing, except that the increase is more rapid. The platforms being about 2¼ inches apart, there can only be a movement on the part of each of 1⅛ inches before they touch. In this movement the buffers are forced back on the springs, *G*, to that extent which, in addition to the first inch gained in coupling up,

Fig. 5.



makes 2⅛ inches. While this movement is going on, however, the lower end of the horn, *L*, being firmly mortised into the coupler and moving with the same, has, by its contact with the yoke-lever, rocked the same on its pivot, throwing forward the equalizer 1⅛ inches, thus producing in all about 3 inches compression by the time the platforms have touched. In addition to this resistance (the object of which is to prevent the butting of the platforms except in case of collision), the spring, *N*, which acts in the two-fold capacity of buffer and draft, is shortened, so as to limit its movement to 1¼ inches, and enable its full resisting power to be utilized in this movement.

To overcome the increased difficulty in starting trains, caused by shortening said spring, another and lighter spring, *O*, is added, which, when the draft is applied, yields first.

By this arrangement the inertia in starting heavy trains is much more easily overcome than by the ordinary 8 in. draft springs.

The brace, *C*, Fig. 5, is designed to sustain the platform, and is admirably adapted for this purpose.

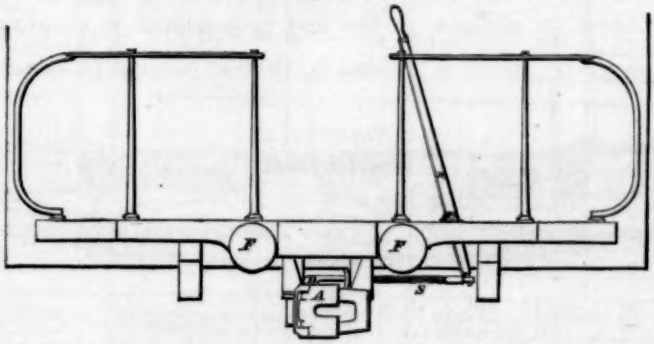
The construction of the intermediate mechanism is such that no amount of pressure upon the buffer-heads produces any counteraction on the draft-springs, *O* and *N*.

Some of the advantages of this improvement have been referred to in the foregoing description, but there are others which deserve special mention.

It is claimed for this device, that by its use telescoping is more effectually prevented than by the use of any other, and for the following reasons :.

In addition to the platforms being elevated to a line with the sills of the car-bed, they are brought and kept in closer contact, making of the entire train one elastic structure. Besides, the couplers being

FIG. 6.



closely interlocked, and acting constantly so as to sustain each other against lateral movement, the platforms are prevented from sliding by each other or buckling, as is the tendency in collisions. Practical demonstration has been had of this in several collisions that have occurred, and where no damage or injury was sustained.

Another advantage possessed by this improvement (the absence of which would have been fatal to its adoption by the roads now using it) is that under no circumstances, it is believed, can the train part accidentally. Experiments were made to test this fact, in the following manner. The two rails of the track were cut and elevated about 2 feet above the track level (triangular blocks of equal sides being used to aid the wheels in mounting and descending), and the train run back and forth over the obstruction a number of times, without parting or any injury resulting.

An accident occurred to a train of five cars running at the rate of fifty miles per hour, in which the truth of the foregoing was fully established. The middle car in the train, in passing a curve, was thrown from the track and toppled over to an angle of nearly 45°,

and held by the coupler in this condition until the train could be stopped, when it was found that the body bolts and axle were bent, but this car with its fifty passengers, as well as the whole train, saved from complete destruction by this improvement, which was found still to be in perfect condition.

The reasons for this will be understood when it is noticed that the coupler of one car extends, and always remains, under the opposite platform, and *vice versa;* consequently, neither platform can fall below the coupler of the opposite car.

Still another advantage, is that by the peculiar construction of the coupler, being a closely-fitting joint and without longitudinal or lateral play, the unpleasant oscilation or swinging of the platforms in opposite directions is overcome, thereby adding greatly to the comfort as well as safety in running trains.

There can be no doubt whatever, that greater steadiness and smoothness, as well as more perfect security, is obtained by the use of this improvement, than has been heretofore.

Its adoption, as a whole, by the Pennsylvania Railroad for its main line and all the lines it operates or controls, and by the Pennsylvania Company for its immense system west of Pittsburg, after a thorough and exhaustive test covering a period of nearly four years, is sufficient of itself to indicate its importance and value.

SELF-LUMINOUS CLOCK DIALS.

By Henry Morton, Ph. D.,
President of the Stevens Institute of Technology.

My attention having been drawn to the "luminous clocks" which have recently been offered for sale in several places, I made an analysis of the substance with which their dials are coated, and found it to consist of nothing but the well-known phosphorescent compound, sulphide of calcium, attached by means of some resinous medium, like varnish.

But while the material in its composition is far from novel, something or other in its method of manufacture and consequent condition, gives it such intensity of properties as has never been approached before.

In the cabinet of the Stevens Institute are numerous specimens of phosphorescent powders (sulphides of calcium, barium, and strontium), which represent the best products heretofore obtained. These, if exposed to strong sunlight or to an electric discharge, or the like, will glow for many minutes in the dark.

One of these clocks, however, I found would continue to glow with sufficient brightness to be visible across a room all night, and could be read at any time if approached closely.

After being shut up in a box for five days, this clock was still visible in total darkness, when the eyes had been rendered sensitive by remaining in the dark for a few minutes.

This clock dial is also readily "excited" by lamplight or gaslight, or indeed by any source of light containing rays above the yellow of the spectrum.

The light from a Bunsen burner with soda in the flame, if filtered through yellow glass, will not excite it however, but if the yellow glass is omitted, the blue rays of the Bunsen burner flame will serve to excite the phosphorescence of this remarkable material.

The cause of this action is believed to be somewhat as follows: When light falls on certain bodies, its vibrations cause molecular changes which are not permanent, but are only maintained by the action of the "exciting" vibrations, somewhat as a mass of plastic substance can be kept in a soft condition by constant stirring. When the exciting cause is removed, the molecules return to their normal positions, and in so doing, set up vibrations which are the cause of light, very much as the solidifying of water evolves heat.

Thus these bodies, when exposed to daylight, absorb as it were the light energy, and re-emit the same afterwards.

The phosphorescent property of sulphide of calcium has been known since 1768, when Canton prepared it by heating together intensely for an hour, three parts of calcined oyster-shells, with one part of sulphur. Its properties in this relation have been elaborately studied by Becquerel, who published his researches in the *Annales de Chimie et de Physique*, and has also devoted a large part of the first volume of his book, "La Lumière," to this subject. He found that by employing lime in different forms, such as Iceland spar, marble, oyster-shells, aragonite, etc., products emitting different colors by phosphorescence, such as orange, yellow, green, blue and violet, were obtained.

The light given out by these clocks is a violet blue, like that which Becquerel produced with aragonite, but Becquerel makes no mention of anything whose duration of luminosity approaches that of these clock dials.

In making up some of these preparations, I have noticed that out of the same batch, some portions will glow by phosphorescence much more brightly than others, so that evidently this difference depends upon some very small structural or molecular variation, and there can be little doubt that it is by some method of securing a desirable condition of this sort, that the remarkable efficiency in these clock dials is attained.

If still further advances should be made in this direction, it is easy to imagine some very wonderful results, before which even Mr. Edison's new electric burner will fade into insignificance.

Thus, if our walls were painted with such a substance, they would absorb light enough during the day to continue luminous all night, and thus render *all* sources of artificial light useless, superseding even the new electric burners, no matter how little they might cost, for it would then only be necessary to provide curtains, which could be drawn over the walls, like shades over windows, when *darkness* was desired. The coloring of houses on the outside with a like material would also evidently obviate the need of all street-lamps.

I do not, like some of Mr. Edison's friends, in reference to his new electric burner, expect that this *still more remarkable and economical* source of light is certain very shortly to displace gas and all other sources of artificial illumination, but if conjectures are to be the order of the day, I do not see why this conjecture is not as good as many others which have been made.

Seriously, this new form of the phosphorescent sulphide of calcium, made of the cheap materials, sulphur and lime, is a truly wonderful substance, which may well suggest strange possibilities for the future.

Composition of Elements.—By reasoning from analogies furnished by the action of known compounds, Lockyer finds evidence that many of the supposed chemical elements are really compound. He has devoted three years' careful research to a comparison of chemical spectra with spectra of various heavenly bodies.—*Comptes Rendus.* C.

THE WATER-SUPPLY OF THE KINGDOM OF WÜRTEMBERG.

Although we live in a comparatively new country, where few streams are as yet seriously polluted by a dense population, or by manufacturing industries, we have already begun to feel the disadvantage of the individual action, with reference to water-supply and sewerage, of different towns in the same drainage-area or river-basin. The difficulties increase in proportion as a country becomes more densely populated, and it is easy to explain the great interest which has been excited in England by the congress lately held under the auspices of the Society of Arts, at the suggestion of H. R. H., the Prince of Wales, to consider the question of the "National Water-Supply."

It is true that the State legislatures exercise a general control over the establishment of water-works, but any one who has watched the passage of a bill through the legislature or the legislative committee, knows the variety of interests which determine the advocating or the opposing of such a scheme. It would be of great present advantage, if there were in each State some central authority charged with the general oversight of the available sources of water-supply. That something of the kind will eventually prove necessary, admits of little doubt. In this connection something may be learned from the experience of the Kingdom of Würtemberg,* which, as it has an area of about 7500 square miles, may be compared, as far as to size, with the State of Massachusetts.

In the year 1869, there was created, in the Kingdom of Würtemberg, a new office, that of "Staats-Techniker für öffentliche Wasserwerke." It was made the duty of the Staats-Techniker to superintend the planning and construction of all public works for the utilization of the available river and spring waters, and to advise, in

* Das öffentliche Wasser-Versorgungswesen im Königreich Württemberg. Denkschrift aus Anlass der internationalen Ausstellung für Gesundheitspflege und Rettungswesen in Brüssel verfasst von Oberbaurath v. Ehmann. Stuttgart, 1876. 4to, pp. 137.

This work being printed for private distribution only, is not readily obtained. Abstracts are to be found in the Correspondenzblatt der niederrheinischen Vereins für öff. Gesundheitspflege, vi (1877), p. 99; and in Grahn's städtische Wasserversorgung, i, pp. 4-9.

matters of water-supply, the local authorities of any village, town or city within the kingdom,—this advice including the preparation of plans and estimates, and being without cost to the community asking the advice.

The first to fill this office was the present incumbent, Dr. von Ehmann, an engineer of long practical experience, and well acquainted with the local conditions.

The extent to which the creation of such an office met a felt want, appears from the statistics which follow.

The number of communities availing themselves of the services of the Staats-Techniker with a view of introducing a system of water-supply, was as follows:

	Urban.	Rural.	Total.
During the year 1870,			70
" " " 1871–2,	33	61	94
" " " 1873,	13	19	32
" " " 1874,	15	26	41
" " " 1875,	16	40	56
			293

Previous to 1870, works had been constructed for supplying 45 communities with water, and up to January 1, 1876, there have been carried out, and brought into actual operation, 96 distinct works, in addition to those undertaken for supplying the so-called "*rauhe Alb*," to which allusion will presently be made; so that, during a period of ten years, 130 localities, or one-fourth of the entire number in the kingdom had been supplied with water.

The most interesting part of the work has been the supplying water for the "rauhe Alb." This district, which lies from 750 to 800 metres above the level of the sea, and some 300 metres above the surrounding low lands, has a width of some 33 kilometres, and is of such a geological character that the rain-fall quickly disappears in the clefts of the limestone or dolomitic rock, and does not appear again in springs within the region. The surface and rain-water collected by the inhabitants in cisterns and in puddled cavities in the ground, was not only inferior in quality, but so insufficient in quantity that often in cold or dry weather it was necessary to bring water from the valley below, a distance of from 2 to 12 kilometres.

The plans for supplying this district, containing between 60 and 70 villages, with some 40,000 inhabitants scattered over an area of 22 square miles, were devised by Dr. v. Ehmann, and, although at first

there was some opposition, principally on account of the attendant expense, the plans were finally adopted, and have been already carried out to a considerable extent, generally with aid from the State.

The villages are divided into 9 groups, each group forming a unit for purposes of water-supply. The water is taken partly from natural springs in the lower land, and partly from the ground-water by means of wells and galleries, and is pumped by water-power to the plateau above.

The height to which the water has to be forced in order to reach the various distributing reservoirs, as well as other details, may be learned from the following table:—

Group.	No. of communities.	Total inhabitants.	Amt. of water in cubic metres per day.	Height to which water is lifted in metres.	Length of mains in metres.	Source of water.
I	9	7525	600	265	34,000	Springs.
II	8	7600	570	300	50,000	Ground-water.
III	8	3600	270	180–255	30,000	Ground-water.
IV	8	3700	280	117–200	32,000	Springs.
V	9	3800	280	320	50,000	?
VI	7	1700	130	180	28,000	Springs.
VII	9	2000	170	220–230	30,000	Springs.
VIII	6*	4300	300	200		
IX	4	2900	200	173–230	25,000	Springs.

Besides bearing the expense of the preliminary surveys, of the plans, and of the superintendence of the work, the State contributed in some cases 25 per cent. of the cost of construction, and the work had progressed so far, that, at the time of the last published report —the summer of 1876—five of the groups, comprising 34 villages, with 17,010 inhabitants, were provided with a supply of water amounting to 1232 cubic metres per day. The total length of pipe laid, up to that time, was 144,000 metres.

While the problem of supplying a district of such size with water, which must be raised vertically to a height of from 200 to 300 metres, and where the force-mains are from 3 to 10 kilometres in length, is an interesting one to engineers, the coöperative idea, by which the various villages and towns are treated as parts of one whole, is interesting to all who are engaged in matters of water-supply. W. R. N.

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* In this district a portion only of the villages, namely, three, were supplied with water.

Geological Relations of the Atmosphere.—T. Sterry Hunt has investigated the geological bearings of the hypothesis of a universal atmosphere, which was proposed by Sir William Grove, in 1843. He believes that the carbonic acid, which is included in the calcareous and dolomitic rocks, must have had an extra terrestrial origin, and that such an origin can be readily accounted for, by supposing that our atmosphere is part of a universal cosmical medium, which is condensed around centres of attraction in proportions depending on their masses and temperatures, and occupying all the interstellar spaces in a state of extreme rarefaction. Many considerations go to show that the atmospheric changes did not permit a glacial temperature at the sea-level until towards the end of the tertiary epoch. Matthieu Williams used the same hypothesis, in 1870, to account for solar heat, and Hunt employed it, in 1874, to explain the origin of nebulæ and the generation of elements by a cosmical chemistry, in accordance with the ideas of F. W. Clarke and Lockyer.—*Comptes Rendus.*

C.

Preservation of Iron.—Capt. Bourdon has devised simple forms of apparatus for coating iron with Barff's magnetic lacker. In the course of his experiments he found that the coat of oxide could be formed by the air, in the following manner; The serpentine part of a sheet-iron reservoir, communicates with air which is heated to 120° (248° F.). The current of hot air, after circulating through the serpentine, reaches the cylinder which contains the articles to be lackered. The escape-spout communicates with a water-aspirator regulating the flow of air, which should be very gentle. The internal pressure is little more than one atmosphere, the apparatus being in communication with the open air. The temperature of the air in the cylinders is 280° (536° F.); the operation lasts five hours, giving a coat five-hundredths of a millimetre thick (·002 in.), of a beautiful greenish black, resisting the action of fine emery-paper and of dilute sulphuric acid. After the articles are taken from the cylinder, they are rubbed with a greasy rag, and spots are removed by fine emery-paper or scouring-grass. Spots may generally be avoided by suspending the pieces, so that they will not touch each other or the walls. If the temperature is raised to about 300° (572° F.), a thick coat is secured, but it is apt to scale. Articles thus lackered have been exposed to snow and rain for a month

without getting any spots of rust. If the black coating is removed by emery-paper, there is a grayish layer on which rust does not take much hold; the spots can easily be removed by a bit of hard wood. Barff has observed the same peculiarity in articles which have been steam-lackered.—*Ann. des P. et Chauss.* C.

Night-Temperatures at Different Altitudes.—It is often warmer upon mountains than in valleys, especially in severe winters. M. Alluard has found evidences, at the observatory of Puy-de-Dôme, of frequent similar inversions at night, by tracing: 1. The curves of minimum temperature, in the two stations of the observatory. 2. The curves of maximum temperatures, obtained under the same circumstances. 3. The curves of the mean temperatures of the two stations, deduced from the maxima and minima. The curves of minimum temperature often intersect, in summer as well as in winter, so that the summit of the mountain is sometimes 5° (9° F.) warmer during the night than the base. There is no similar intersection in the curves of maximum temperature. The inversions occur most often when the upper and lower currents are from different quarters, but sometimes when the two currents have the same direction. Further observations are needed in order to find the cause of the anomaly.—*Comptes Rendus.* C.

New Lunar Crater.—Dr. H. J. Klein, in Cologne, has been watching the moon's surface with special care for about twelve years. Most of the investigations of the last century, by Schröter, Herschel, Mädler and others, have failed to discover any active volcano in the moon, so that the opinion has become general that our moon is a dead world, a burnt out and fossil heavenly body. This opinion must now be given up, since there is evidence of the present activity of powerful forces upon the moon's surface. Dr. Klein has discovered a crater near the centre of the visible hemisphere westward of Hyginus, in a broad level plain, appearing at the time of the first quarter as a dark shadowy gulf of about 4,000 metres (1·24 miles) diameter. Its inner surface exceeds all the present active craters of the earth, except that of Kilauea in Hawaii. Further observations which have been undertaken, especially in England and America, will doubtless show whether its activity still continues.—*Deutsche Rundschau.* C.

Periodic Movements of Flowers and Leaves.—The motions which have often been described, under the names of the *sleeping* and the *waking* of leaves or flowers, may be referred to a special point, at the base of the organ, which may be called the *motor tubercle.* The mechanism consists of modifications in the energy with which this tubercle supports the movable organ, an energy which is gradually restored during the night, and gradually exhausted during the day. P. Bert has shown that these facts may be explained by supposing the alternate formation and destruction, in the tubercle of some substance which has a great endosmotic power. Having accumulated in great quantity towards the end of the day, it absorbs the water which gives the nocturnal tension, while its gradual diminution during the day allows gravitation and other forces to require an ascendancy. This material is formed under the influence of the red and yellow rays of the solar spectrum, and is destroyed in darkness, or by the action of the blue-violet region; its collection, its formation and its absorption of water reduce the temperature of the motor tubercle, which is colder than the surrounding air and than the contiguous points of the stem. By a series of ingenious experiments and chemical analyses, Bert satisfied himself that the active absorbing ingredient is grape-sugar, which is prepared in the leaflets, under solar action, and accumulates towards night in the motor tubercle. The design of the movements seems to be, to reduce the evaporating surfaces to a minimum. Even the irritability of the sensitive plant is a protection against evaporation by the wind, which is the only agent that often disturbs the plant, when in its natural conditions. The common impression, that changes of evaporation play an important part in the movements, seems to be erroneous. If a sensitive plant is completely submerged, the spontaneous motions continue for about eight days; the only difference being that the sleep begins about an hour earlier and ends about an hour later than usual. The destruction of the grape-sugar goes on even during the day, under the direct influence of the luminous rays. This may be shown by placing a drop of common ink on the tubercle of a main petiole of a sensitive plant; the leaf immediately bends so as to show an increase of the subjacent energy. A drop of red ink produces no effect; but if a bit of India-ink is added, the petiole gradually moves, as the India-ink dissolves.—*Comptes Rendus.* C.

The Sun's Surface.—At one of the sessions of the French Association, Janssen described the apparatus which enabled him to take photographs with an exposure of $\frac{1}{100000}$ of a second, and explained the new information which such photographs have furnished respecting the upper surface of the photosphere. The polar regions are covered with a general granulation, of forms, dimensions and distribution very different from the ideas which have been derived from optical examination. Resemblances to willow-leaves, rice-grains, etc., may be occasionally traced in single points, but the prevailing and fundamental form is spherical, and the "grains" appear to be clouds of dust or mist floating in a gaseous medium. The luminous intensity of the sun resides chiefly in a few points, so that if the whole surface was as bright as the most brilliant portions, its luminosity would be increased from ten- to twenty-fold.—*La Nature.* C.

Curious Case of Heating.—M. Hirn reports some observations connected with the adjustment of the fly-wheel of a steam engine. In driving a large pin, one of the assistants rested against its head one end of a cylindrical iron bar about 1 metre (39·37 inches) long and 8 centimetres (3·15 inches) in diameter. Another workman drove the pin by striking upon the free end of the bar. The operation had hardly been begun, when the first man stated that at every blow he felt the bar grow very warm and suddenly cool again. M. Hirn, taking his place, found, to his great astonishment, that there was a great change of temperature, which he estimated at about 35° (63° F.). The hammer weighed about 5 kilogrammes (11 lbs.); the workmen lifted it about 2 metres (6·56 feet); supposing that the impulse of the arms added a velocity equivalent to a fall of 3 metres (9·84 feet), the increase should have been only 0·13° (0·23° F.), or only about $\frac{1}{230}$ of the observed effect. M. Hirn regards the phenomenon as subjective, and explains it as follows: "In order to observe the phenomenon it was necssary to stand very near the bar, with the head near the path of the hammer, and to seize the iron at about 1 centimetre ($\frac{3}{8}$ inch) from the end which was struck. This required firm faith in the skill of the workman who was wielding the hammer. I hesitated at first, and seized the bar at some distance from its end; nevertheless, I felt a strong sensation of heat, the source of which seemed to be in the interior of the hand, and not on the surface of the metal. When I became bold enough to take the proper position, the iron seemed to heat and cool rapidly at every

blow, the sensation of heat continuing only as long as the sonorous vibrations which were excited in the bar by the blow. The best explanation of these facts, as it seems to me, is to suppose that under certain special circumstances sonorous vibrations, by agitating the sensitive nerves, excite a sensation of heat at the surface of the body analogous to the sensation of light which is produced in the eyes by a blow. This explanation, which I offer with some hesitation, may perhaps be tested by a Melloni thermometer, by observing whether a bar of iron, when struck at one end, really becomes heated during a short interval, so intensely as seemed to be the case in the experiment which I have just related."—*Comptes Rendus.* C.

Harmless Colors.—Brilliant colors are generally preferred for candies and children's toys; thus, for red and orange, vermilion and red lead are often used; for yellow, chromate of lead; for green, arseniate of copper or Scheele's green and Schweinfart green. For red, orange and intermediate hues, harmless colors have been hitherto unknown. M. Turpin has obtained, by combining oxide of zinc and cosine, red lacs, which resist the action of light and profitably replace the finest commercial vermilions. By adding chromate of zinc in varying proportions, these lacs yield lively colors, which may be used as substitutes for red lead and chrome yellows. With ultramarine, they furnish good violets. These products are unchangeable under the action of light or heat, and can therefore be incorporated in caoutchouc paste mixed with sulphur, oxide of zinc, etc., and exposed to the vulcanizing process without the least change of color.—*Bull. de la Soc. d'Encour.* C.

Utilization of Water-Power at Rock Island.—This improvement, intended to furnish water-power to the Government works, begun in 1867, is now complete.

It consists of a canal, 2000 feet long, 200 feet wide at the top, and 175 feet at the bottom, and involved the removal of 10,341,000 cubic feet of rock. There are two dams: the upper being 230 feet long and containing 418,250 feet of masonry; and the lower dam, 726 feet long and containing 168,000 feet of masonry. The supply of water is expected to be 20,000,000 feet per hour and to develop 2000 horse-power.

The power is transmitted by two shafts, 350 feet long, each driven by twenty water-wheels.—*Engineering News.* *

Strength of American Railway Cars.—On the 23d of October, 1878, a southeasterly gale prevailed in the Middle States, which was very severe at Philadelphia.

The anemometer of the Signal Service recorded a velocity of the wind of seventy-five miles an hour. Several steeples were blown down, and several hundred houses unroofed and otherwise seriously damaged.

Among the structures thus injured, was the depot of the Pennsylvania Railroad, West Philadelphia. It consisted principally of a main building, for waiting-rooms and offices, and two sheds, each 70 feet in width, and about 800 feet in length, extending northward from the main building, and on the side of the hill bounding the Schuylkill on the west. Immediately east of the depot, and about 25 feet below, are the tracks of the Junction Railroad. From its situation, the eastern shed was greatly exposed to an easterly storm. During the gale of October 23d, about 7 o'clock A. M., the shed was blown over upon several trains of cars, which were under it, ready to be dispatched.

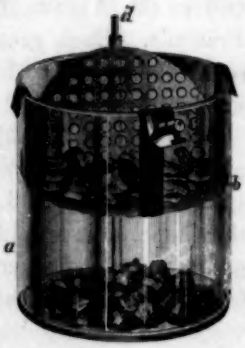
So great was the strength of these cars, that they held up the wreck. The 10-inch cast-iron columns, 25 feet long, that supported the roof-girders, fell, in many cases, directly against the cars with the force due to their own weight and that of the whole roof, probably at least 6 tons to each column, impelled by the force of the wind added to that of gravity.

Notwithstanding this, not one of the cars was wrecked. In one instance, a column struck a car near the middle, and snapped off, but the framework of the car was not broken; the lower part of the column rested against the car—the upper part on its roof.

It has been frequently remarked that in railroad accidents in England, the fatality and wounding are greater than in the United States, owing to the fact that the English cars are not built to stand any extraordinary blow, and in the event of a collision or derailment, the cars are splintered to a greater extent than in this country; but it is so rare that a test like the above occurs, that we think it worthy of a permanent record.

A car that will stand, without injury, the impact of a 10-inch cast-iron column, with 6 tons of extra weight, driven by a gale of seventy-five miles an hour, contains an excess of strength that is very assuring to the traveler. R.

Dr. S. M. Plush Battery Cell.—This battery cell is a modification of the Callaud battery, and consists of the glass jar, *a*, of the usual proportions, having at the bottom a copper plate upon which is placed sulphate of copper, and has attached to it the insulated wire, *d*, forming the positive pole. About half-way down the inside of the glass jar is the shelf, *b*, a perforated sheet of copper, upon which is placed pieces of zinc of any form. The shelf is suspended by three strips of copper, one of which, *c*, constitutes the negative pole. With this form of cell, the zinc of commerce can be broken into pieces of suitable size and used without any other preparation, and the zinc can all be consumed; while in the Callaud battery, the zinc must be cast into suitable form, involving some loss of metal and expense, and as a considerable percentage of the zinc of such castings is not consumed it must be re-melted at still further loss. Another advantage is that the sulphate of copper can be fed into the bottom of the cell through the opening left by turning up one side of the shelf, *b*, and broken zinc placed upon the shelf, without disturbing any of the connections, thus making the battery absolutely continuous. Objection has been urged that there will be local action between the zinc and the copper of the shelf, but Dr. Plush holds that practically no such action can take place, as there is really no closed circuit between the pieces of zinc and the copper. Lead may be substituted for copper in making the shelf, *b*.



Cost of Street Lighting by Electricity in Paris.—At a recent meeting of the Society of Arts, Mr. Jas. N. Shoolbred read a paper "On the Practical Application of Electricity to Lighting Purposes," giving the particulars of cost of plant and of operating electric lights under a variety of circumstances, and by several different systems.

Of the various streets and other places in Paris, lit up by the Jablochkoff system, the Avenue de l'Opera is the one which, from its central position, has attracted most attention, and therefore, will be taken here as a type example.

The Avenue de l'Opera, including the Place de l'Opera at one end, and the Place du Theatre Français, are lit up by 62 lights; 46 single-

candle and eight double-candle (on the Place de l'Opera). Originally, only about 40 were provided, but the illumination being insufficient, the number was augmented (at the contractor's expense) to the amount just stated.

These are divided into four groups; one on the Place de l'Opera, two in the Avenue de l'Opera, and one on the Place du Theatre Français. Each group of lights is supplied with electricity from a (double) Gramme "16 light" machine, driven by an engine of 20 nominal h. p.

A very considerable amount of mystery has been kept up by the patentees of this system as to the cost of it. The expense they state it to be is (1·06 francs) 11*d.*, nearly, per light per hour, which they hope, so it is said, shortly to reduce by one-half. However, the payment to the patentees by the City of Paris is at a rate of 1·25 francs per hour on each of the original lights stipulated in the contract, the augmentation to 62 being entirely gratuitous by the contractor and in order to keep up an effective illumination. The total remuneration is 37·2 francs (29*s.* 9*d.*) per hour. The original gas illumination consisted of 344 jets, and costs 7·224 francs (6*s.*) per hour. The electric illumination is considered, however, as equal to 682 gas jets, say, to double the original illumination; that is, to a cost of 14·45 francs per hour, as against 37·2 francs for the electric one. The latter, therefore, cost 2·6 times that of the gas of equal illuminating intensity.

Need it be added that the City of Paris have terminated the contract with the last day of November.

The contractors have, however, offered to continue the contract at the reduced rate of 0·60 francs (6*d.*) per light per hour. The Municipal Council of Paris have declined to continue any contract, except provisionally, up to January 15th, 1879, and that only at the rate of the original cost of the gas, viz.: at a total expense of 7·224 francs (6*s.* nearly) per hour. By information lately received from Mons. Allard, the chief engineer of the lighting department of the City of Paris (under the engineer-in-chief, Mons. Alphand), and by whom the above details have been kindly communicated, the contractors for the lighting, the Societé Générale d'Electricité, have consented to undertake the lighting at the above reduced rate. The price paid to them, therefore, will be, up to January 15th next, at the highly remunerative rate of about 1⅛*d.* per light per hour.

A series of very careful photometric measurements carried out by the Municipal authorities in the Avenue de l'Opera itself with the existing illumination, showed each light to possess a maximum of 300 candles of intensity with the naked light; while by the interposition of the opaque globe, the maximum was reduced to 180 candles (a loss of 40 per cent.), and this again to a minimum of 90 candles during the darker periods through which this light passed.

Many other applications of the Jablochkoff candles with the Gramme machine occur in Paris, such as at the Magazins and the Hotel du Louvre, at the Theatre du Chatelet, at the Hippodrome, at the Hotel Continental, etc. Still, as in none of these cases have the financial results been ascertained on such good authority as in the case of the Avenue de l'Opera, it has been thought advisable to pass them over. The main object, held constantly in view in the present communication, has been to ascertain the carefully prepared financial results of a few applications, which have been supplied on unimpeachable authority, rather than to attempt to present those of a larger number, in some of which the results might have been open to doubt. *

Book Notices.

FORMULÆ FOR THE CALCULATION OF RAILROAD EXCAVATION AND EMBANKMENT, AND FOR FINDING THE AVERAGE HAUL. By John W. Davis, C. E. 8vo., pp. 106. Gilliss Bros., N. Y., 1877.

The second edition of a work, and the fact of it being adopted by the most important schools in a country, is sufficient endorsement of public favor to clearly demonstrate its merits.

The "average haul" has been added; a point of the highest interest to contractors and engineers. We feel sorry that the calculations of the same were not done without the assistance of "calculus," as the so-called "practical men" may be familiar with general mathematics, and not with its higher branches. Those who have these advantages, will be able to understand that the

"average haul" is the distance between the centre of gravity of the material as found, to its centre of gravity as deposited; and also why, when monthly estimates are made, these correspond to the total of the smaller cross-sections, and would consequently be a proof that all previous work had been accurately executed. Those familiar with railroad excavation and embankment, know that this is not the case when the ordinary formulæ are adopted.

We can only say in conclusion that it is to be hoped that the adaptation of Mr. Davis's formulæ will give the exact volume corresponding to regular or irregular sections, and that it is to be greatly regretted that the various mathematical formulæ (that the engineer has at his disposal) for the calculation of earth work do not agree in their final results. W.

METALS AND THEIR CHIEF INDUSTRIAL APPLICATIONS. By C. R. Alder Wright, D. Sc., etc. 12mo, pp. 191. Macmillan & Co., London, 1878.

It is difficult to write on "Metals and their chief Industrial Applications," and show any great originality, as one has at his disposal many thousand examples and theories. Notwithstanding, the author has succeeded, in many cases, in explaining to his reader, in an intelligent and simple manner, several facts pertaining to metallurgy which appear complicated to beginners. He supposes, without a doubt, that we are all familiar with the principles of chemistry and the elements of physics—as it would be hardly possible to comprehend the various processes adopted for native metals, simple ores (oxides, chlorides, fluorides, etc., and also sulphides, carbonates)—nor could we realize the exact meaning of absorption or evolution of heat, nor the calculations pertaining to the value of caloric distubance when the reactions take place at a given temperature. The manufacture of pens, pins, looking-glasses, etc., being the examples chosen to illustrate the industrial applications of the above, have been most judicious, as the comprehension of these does not necessitate deep scientific knowledge, and represents objects with which the general reader is familiar.

We consider the title, *chief* industrial applications, not exact, as but the minor and simpler ones have been mentioned. This little work is written in a pleasing and modest style, and has not the pretension of being complete; but, on the contrary, is but an outline, where the general principles have been observed, a portion of the same being a course of lectures delivered at the Royal Institution of Great Britain, in 1877, by the author. W.

ELECTRIC LIGHTING. A partial treatise, from the French of Hippolyte Fontaine, by Paget Higgs, Assoc. Inst. C. E., etc. E. & F. N. Spon, London and New York, 1878. 8vo, 194 pp. Price, $3.00.

This translation supplies a place in English scientific literature, in giving the fullest information down to the most recent date, in plain, popular language, of the practical operation and mechanism of the electric light. The electrical, dynamic or physical theories, which, in their relations to the production of light or force by electricity, open fields of abstruse interest to the student, are left almost unconsidered, but here will be found, in words that any one can read and comprehend, what has been done to produce the electric light in various ways, what apparatus has been employed in so doing, fully illustrated by well executed wood-cuts, and clearly described in the well printed text. The historical portion is somewhat brief, and the earlier efforts have been left without so full description or illustration as would be wished in a more thorough study, but in Chapter IV the subject of dynamo machines is approached with much completeness, so that the references can be followed if any one desires; and the subsequent chapters, if they do give undue prominence to the machine and practice of M. Gramme, they also convey to the reader a complete view of the working of machines and of lights. In fact, the book is somewhat partisan in its appreciation of M. Gramme and his share in the invention of the dynamo-electric machine, but this advocacy may be admitted, and the work will still have the highest merit.

The relations of three explorers of this field of science may be stated. In 1852, Dr. Page, of Washington, made a machine for a motor on a railroad. This machine had many features in correspondence with the dynamo-electric machines of to-day, and had Dr. Page recognized the fact, and worked upon it, there is a strong probability that it would have been the immediate precursor of a system of dynamo-electric machines. In 1861 and 1864, Prof. Pacinotti, of Pisa, not only devised and constructed an electric motor, but, in the last named year, he described its application and usefulness as a means of producing electric force, in such words that any person could thus apply it. It was like a man's constructing a watch with a key, and giving a written description how to wind it so that it would go, and the watch should never run for want of winding. In 1869, M. Gramme produced his machine, "identical in principle" with that of M. Pacinotti (to use the words of M. Fontaine), and he at once proceeded to press and develop its capability.

* * * The reader is referred to the book under review for more complete information, and if he has any interest on the subject of electric lighting, he will assuredly find this work very interesting.

B.

Franklin Institute.

HALL OF THE INSTITUTE, Dec. 18th, 1878.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 135 members and 31 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting there were 18 persons elected members of the Institute, and the following donations to the Library were reported:

Proceedings of the 12th, 14th to 16th, and 24th annual meetings of the Board of Supervising Inspectors of Steam Vessels. Washington. From the Board.

Circulars of Information of the Bureau of Education. No. 1, 1878. From the Commissioner of Education.

Annual reports of Trustees of the Metropolitan Museum of Art. New York. For 1872, 1873, 1875, 1876 and 1878. From the Trustees of the Museum.

Reports of the supervising architect of Treasury Department. Washington. For 1876 and 1877. From the Supervising Architect.

Report on cold rolled iron and steel, by R. H. Thurston. 1878. From Jones & Laughlins, Pittsburg.

Reports of United States Light-House Board, 1873–75 inclusive. From the Board.

Report of Chief Signal Officer of War Department. From the Chief Signal Officer.

On proposed removal of Smith's Island, by L. M. Haupt. From Engineers' Club, of Philad'a.

Bibliographical Contributions, by Justin Winsor. No. 1. Cambridge, 1878.

Reports of Department of Marine and Fisheries, Canada. For 1868, 1869, 1871, 1873, 1874 and 1877, and supplements 1 to 3 to report for 1874; and 1 to 4 to report for 1877.

From W. Smith, Deputy Minister of Marine, Department of Marine and Fisheries, Canada.

Mode of Combustion in the Blast Furnace Hearth, by J. A. Church. 1878. From the Author.

Short Memoirs on Meteorological Subjects, by C. Abbe.
Dissipation of Electricity in Gases, by D. Bobonlieff.
From C. Abbe.

Specifications and drawings of patents, issued from the U. S. Patent Office, for June and July, 1878. Wash., 1878.
From the Commissioner of Patents.

Transactions of the Royal Irish Academy. Vol. 25, November, 1875; Vol. 26, January, March, May and June, 1876.
Proceedings of the Royal Irish Academy. Vol. 10, 1870.
List of Council, Officers and Members, of the Royal Irish Academy. 1876.
Pharaoh's Daughter; a drama on the plan of the mystery and parable play, etc. London. 2 Vols., 1868 and 1874.
From the Royal Irish Academy.

Meteorology of the North Atlantic, during August, 1873, by Henry Toynbee. London, 1878. 2 Vols. Text and Plates.
Statistical sketch of South Australia, by Josiah Boothby. London, 1876. From the Author.

Bulletins 10 and 12, of the United States National Museum, by David S. Jordan.
Bulletins No. 1, 2d Ser.; No. 3, Vol. 2; and Nos. 2 and 3, Vol. 4, of the United States Geological and Geographical Survey of Territories. Wash., 1875–76, and 1878.
First annual report of the United States Entomological Commission, for the year 1877, relating to the Rocky Mountain Locust. Wash., 1878.
Miscellaneous publications Nos. 9 and 10, of the United States Geological Survey of the Territories. Wash., 1877 and 1878.
First, second and third annual reports of the United States Geological Survey of the Territories, for 1867, 1868 and 1869. Wash., 1873.
Geological and Geographical Atlas of Colorado and portions of adjacent territory, by F. V. Hayden, U. S. Geologist in charge. 1877. From the Secretary of Department of the Interior.

Report of the Chief Engineer of Illinois and St. Louis Bridge Co. Oct., 1871. St. Louis. From the General Manager.

Reports of the Department of Marine and Fisheries, Canada, for 1872, 1875 and 1876; and supplements to reports, for years 1873, 1875, 1876. From Hon. Wm. Smith, Deputy Minister of Marine Department of Marine and Fisheries, Canada.

First to third, and fifth to seventh annual reports of the American Railway Master Mechanics' Association, 1868 to 1870, and 1872 to 1874. From the Secretary of the Association.

Twenty-sixth annual report of the Council of City of Manchester, on the working of the free public libraries, 1877–78. Manchester, 1878. From the Council.

Illustrated catalogue of Morris, Tasker & Co.'s Works, Philadelphia. 11th and 12th classes. From E. Hiltebrand.

Annual report upon the improvement of the South Pass of the Mississippi River, showing the condition of the works on June 30th, 1878. By M. R. Brown. From the War Department, Wash.

Annual report of the Secretary of War, for the year 1878. From the Secretary of War.

The Actuary also reported a resolution from the Board of Managers, asking the appointment of a committee to report upon certain questions in connection with completing the awards of medals recommended by the Committee on Science and the Arts.

The Secretary reported, from the Committee on Science and the Arts, a resolution looking to the same end, and also the recommendation of the award of the Scott Legacy Medal and Premium to D. K. Miller, for his padlock.

Prof. E. J. Houston gave a description of the system of dividing the electric light, devised by himself and Prof. E. Thomson, including a new form of induction apparatus,* and a vibrating lamp using reverse currents, the principle involved in which they think will solve the problem of producing small electric lights economically.

The Secretary's Report embraced the Janney car-coupler and platform;† Dr. S. M. Plush's battery cell;‡ Aldred & Spielman's horse-car rail; J. Reynolds & Son's shaking and cinder-grinding grate; Pike & Heath's hand-pump; and the Needham musical cabinet.

The President announced that in accordance with Section 7 of Article XIV of the By-Laws, nominations should be made at this meeting for a President, Secretary and Treasurer to serve one year, eight Managers and one Auditor to serve three years, and one Man-

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* See page 40. † See page 46. ‡ See page 63.

ager to serve two years, to fill a vacancy in the Board, to be voted for at the annual election, on the third Wednesday in January next; whereupon the following members were placed in nomination:

For President, Wm. P. Tatham and J. E. Mitchell.

For Vice-President, J. E. Mitchell and Henry Cartwright.

For Secretary, J. B. Knight.

For Treasurer, Frederick Fraley.

For Managers, Elihu Thomson, Hector Orr, Cyrus Chambers, Jr., Thomas Shaw, Henry R. Heyl, G. M. Eldredge, J. G. Baker, John Hall, Henry Cartwright, Robert Briggs, Wm. Sellers, J. V. Merrick, Charles S. Heller, J. Smetherst, W. V. McKean, R. E. Rogers, Charles M. Cresson, Wm. H. Thorne, Henry Asbury.

For Auditor, Samuel Mason.

For Representative in Pennsylvania Museum and School of Industrial Art, J. B. Knight.

The President appointed the following members to act as tellers at the annual election, to be held on Jan. 15th, 1879: W. A. Rollin, W. L. Dubois, Wm. Taggart, John Canby, Geo. Gardom, Samuel Sartain, G. M. Sandgran, J. W. Nystrom, Chas. Bullock, J. J. Weaver, W. B. Cooper.

On motion of Mr. Close, it was

Resolved, That in balloting for Managers at the next annual election, those receiving the eight highest number of votes, shall be declared elected for three years, and the one receiving the next highest number of votes, shall be declared elected to fill the vacancy.

On motion of Mr. Heyl, it was

Resolved, That the Secretary be directed to have printed, a sufficient number of lists of nominations, to serve as ballots at the annual election, and also to send one such list to each member, with the notice of the next stated meeting.

On motion of Mr. Eldredge, it was

Resolved, That action on the resolutions from the Board of Managers and from the Committee on Science and the Arts relating to awards of medals, be postponed to the next stated meeting.

The following letter was read: